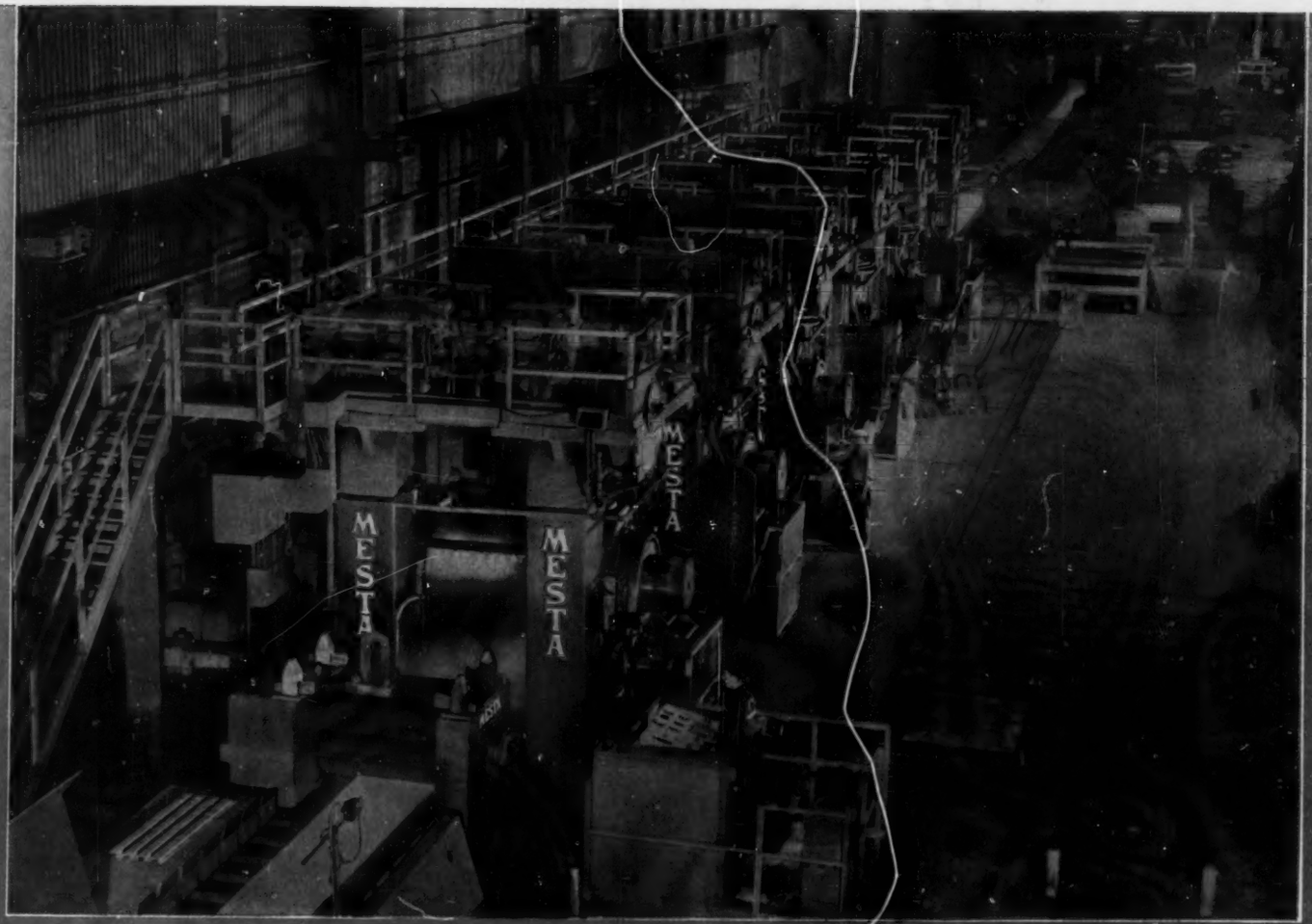
Iron and Steel ENGINEER

ENGINEERING SERVICE TO THE IRON AND STEEL INDUSTRY SINCE 1907

JANUARY 1961



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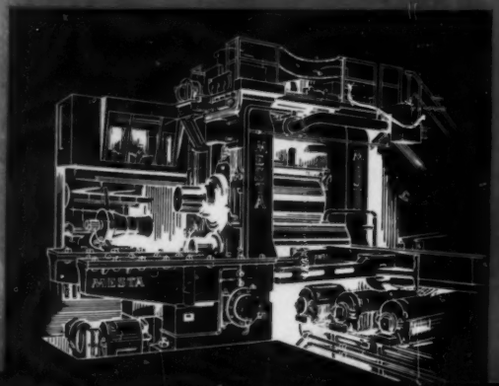

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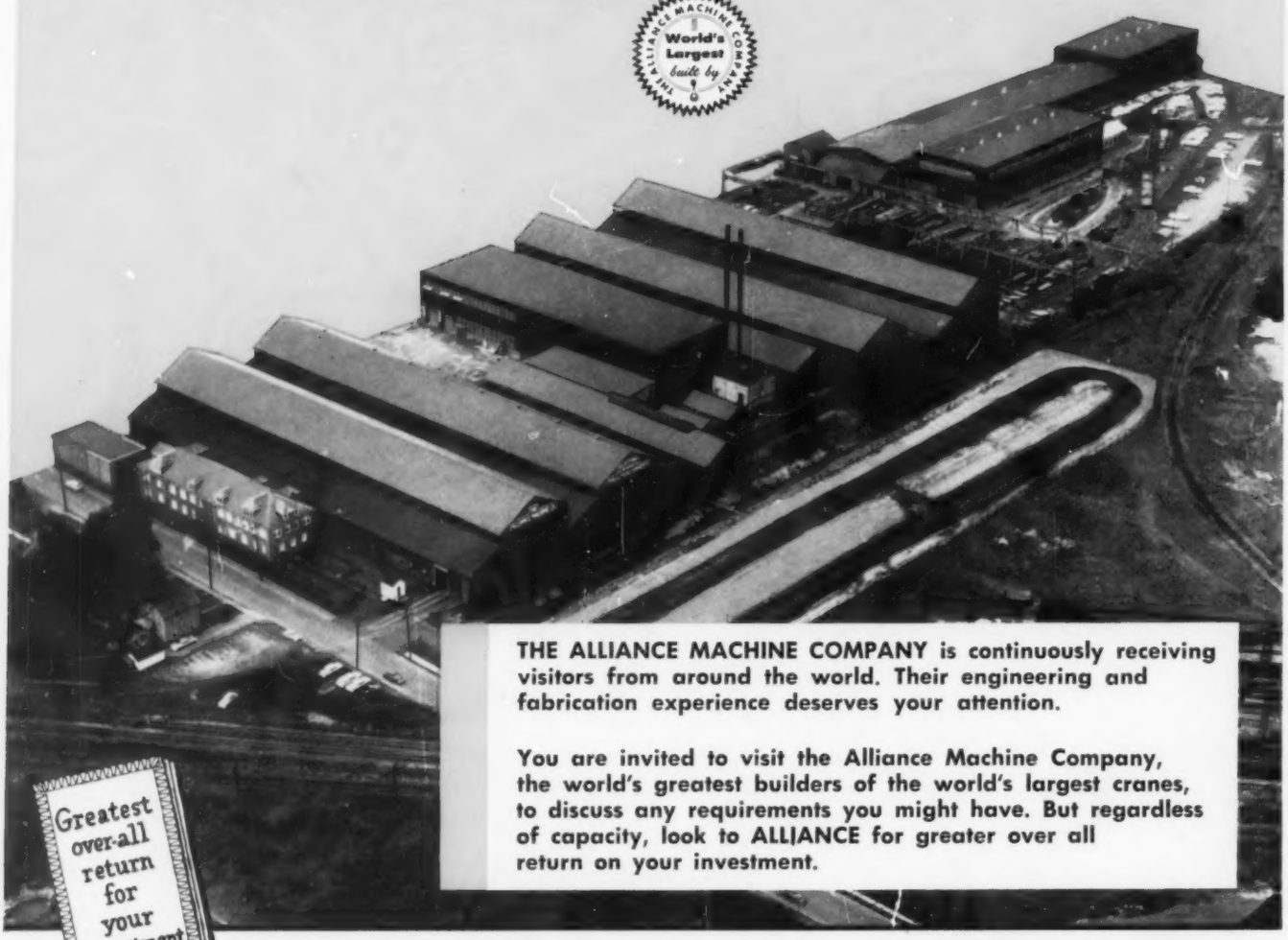
THE HOME OF THE WORLD'S GREATEST BUILDERS OF THE WORLD'S LARGEST CRANES



THE ALLIANCE MACHINE COMPANY is continuously receiving visitors from around the world. Their engineering and fabrication experience deserves your attention.

You are invited to visit the Alliance Machine Company, the world's greatest builders of the world's largest cranes, to discuss any requirements you might have. But regardless of capacity, look to **ALLIANCE** for greater over all return on your investment.

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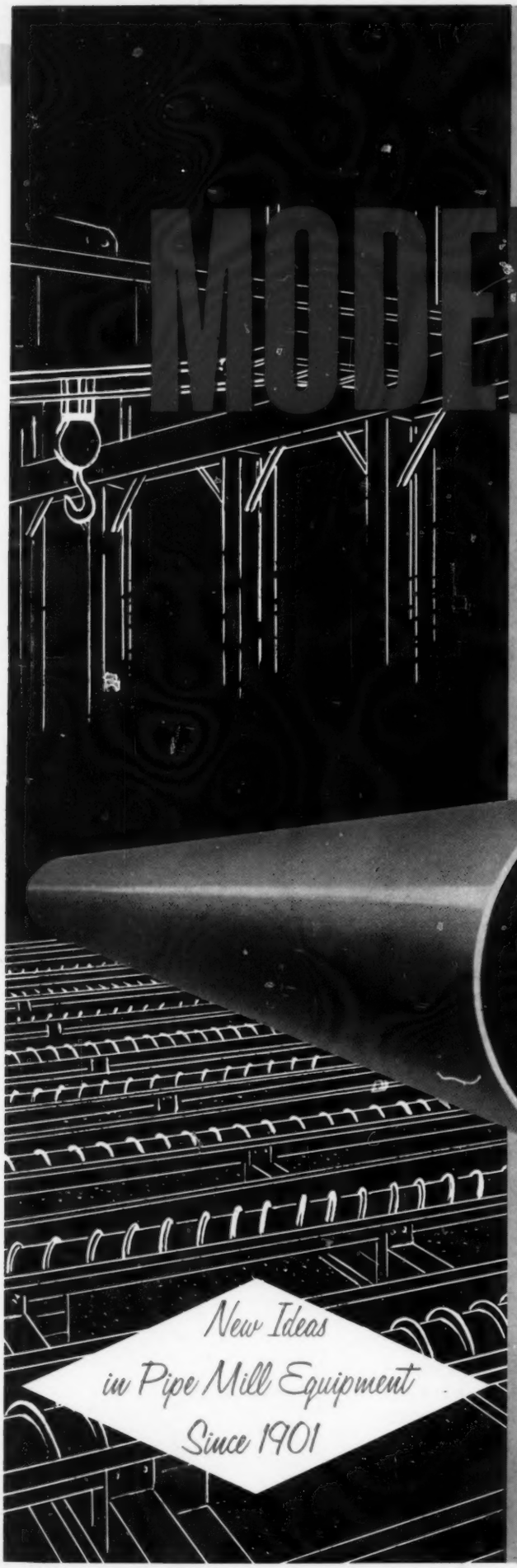

Pipe mills, too, need MODERNIZING

We are doing a lot of work these days on modernizing Continuous Butt Weld Pipe Mills and Seamless Tube Mills.

The continued and projected demand for pipe and tubes makes modernization of mills a must to maintain a competitive position in the business.

Individual items of the mills can be revamped. Existing mills can be rebuilt. Mills can be moved from one location to another.

As the "pipe mill people", we are constantly developing new ideas for new mills and existing mills. These ideas center on two main points: (1) to increase production and (2) to improve the quality of the pipe or tube.

We would like to talk to you about these new ideas and show you how your mills can be made more profitable. Write to Aetna-Standard Division, Blaw-Knox Company, Pittsburgh 30, Pennsylvania.

Aetna-Standard Division

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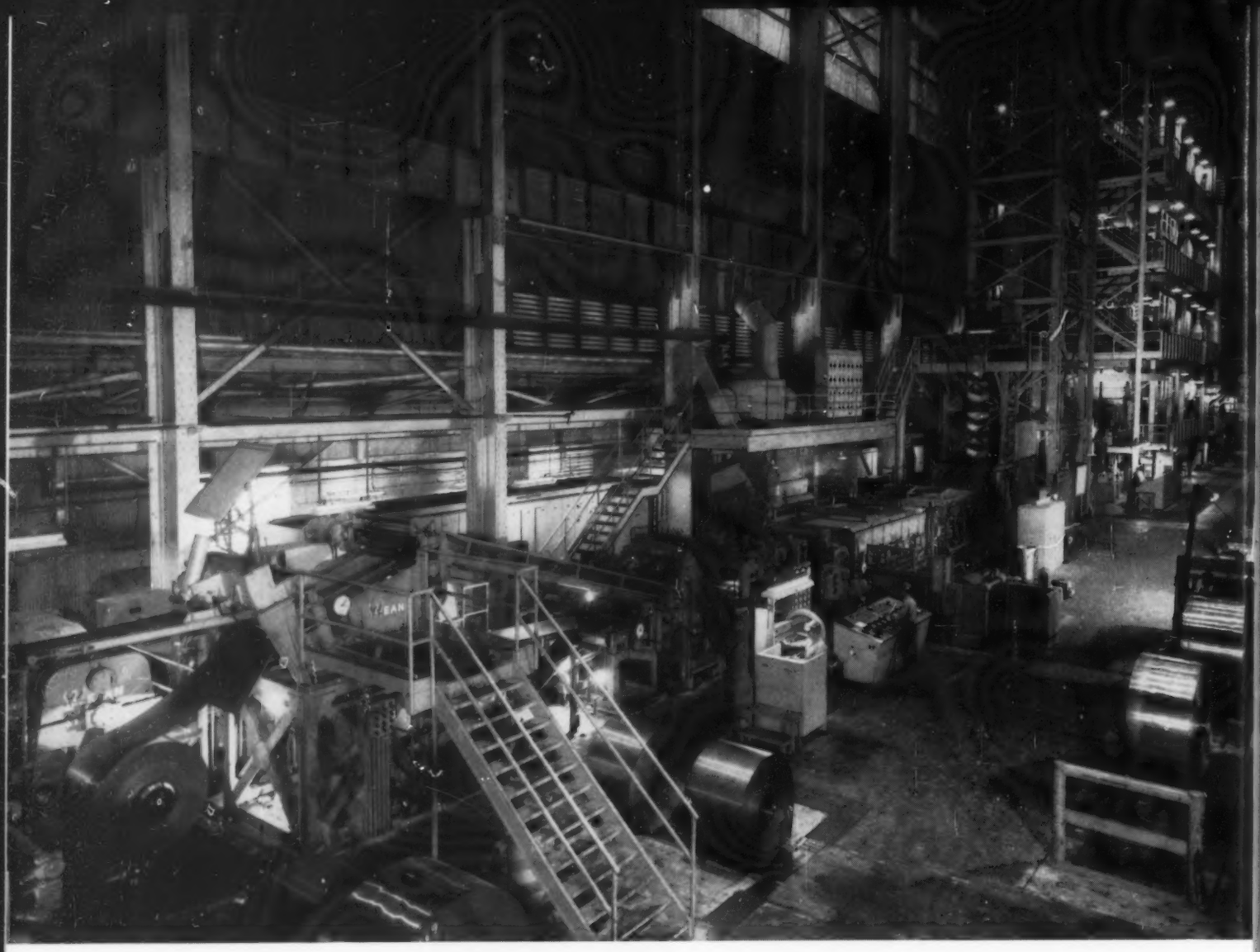

J&L adds modern Wean Annealing Line as major part of tin plate expansion

Recently installed at Jones & Laughlin Steel Corporation's Aliquippa, Pennsylvania plant, this high-speed continuous annealing line represents a major step in J&L's tin plate expansion program. The line is designed to operate at speeds up to 2000 fpm, and it can handle coils weighing up to 50,000 lb with a maximum O.D. of 85".

Strip tension is controlled within the major zones of the line by six precision bridles. The bridle controls are interlocked to provide optimum operating tensions in the looping towers, cleaning zone and furnace. This accurate tension control, coupled with other design features, assures positive tracking of the strip throughout the length of the line.

Off-gauge end scrap is removed at the entry end of the line by a novel system of shifting uncoilers, with a scrap reel located outside of the line. Short sections of scrap are joined by a traversing spot welder in order to build up coils, which facilitates scrap handling.

Thirty-one years of partnership with the steel industry and specialization in continuous steel processing facilities give Wean pre-eminent experience in this field. Whether your planning involves tin plate processing, galvanizing, cleaning or pickling facilities, Wean will be able to "creatively engineer" the equipment to meet your requirements.

WEAN

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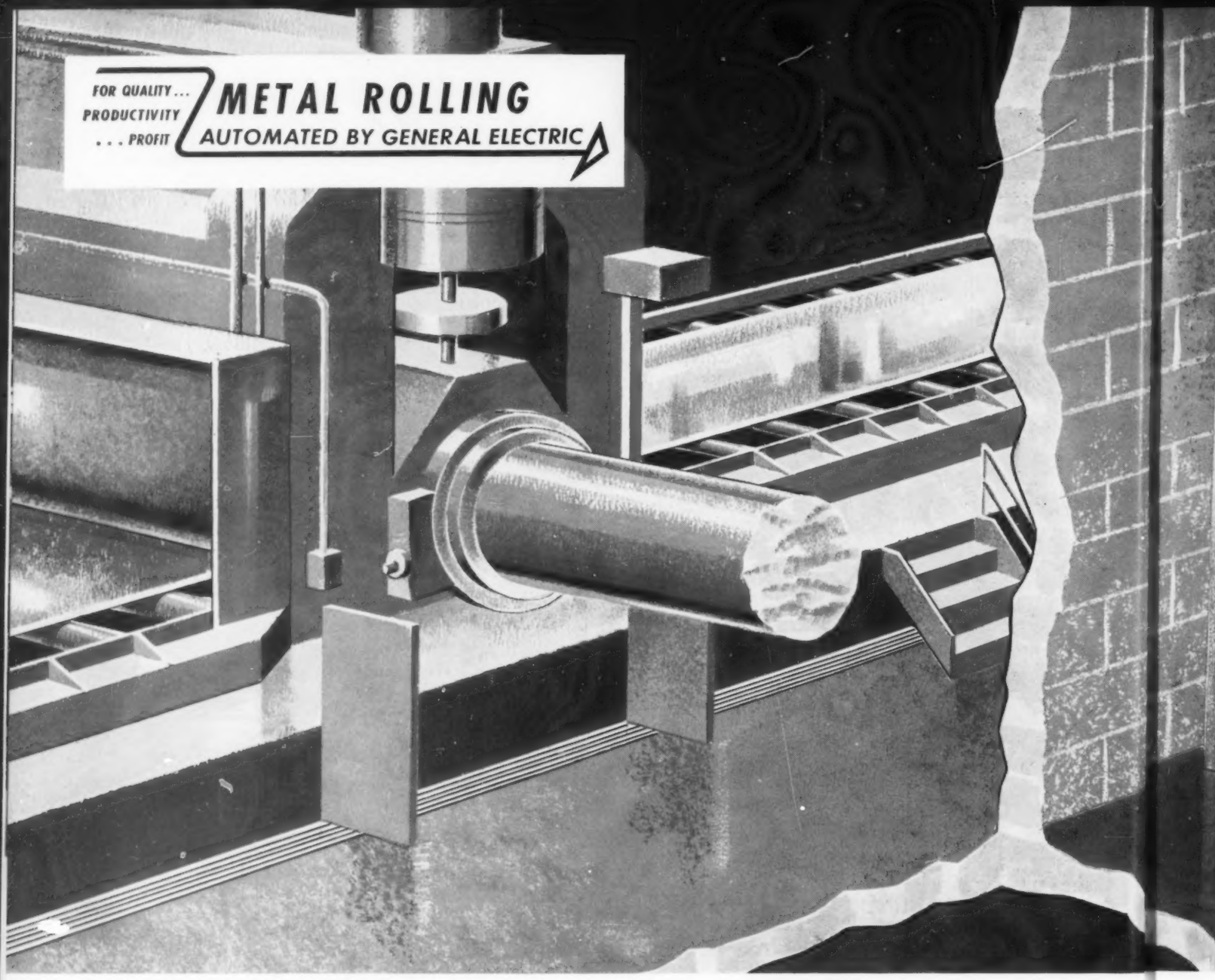


GENERAL ELECTRIC CONTROL FOR STEEL MILLS

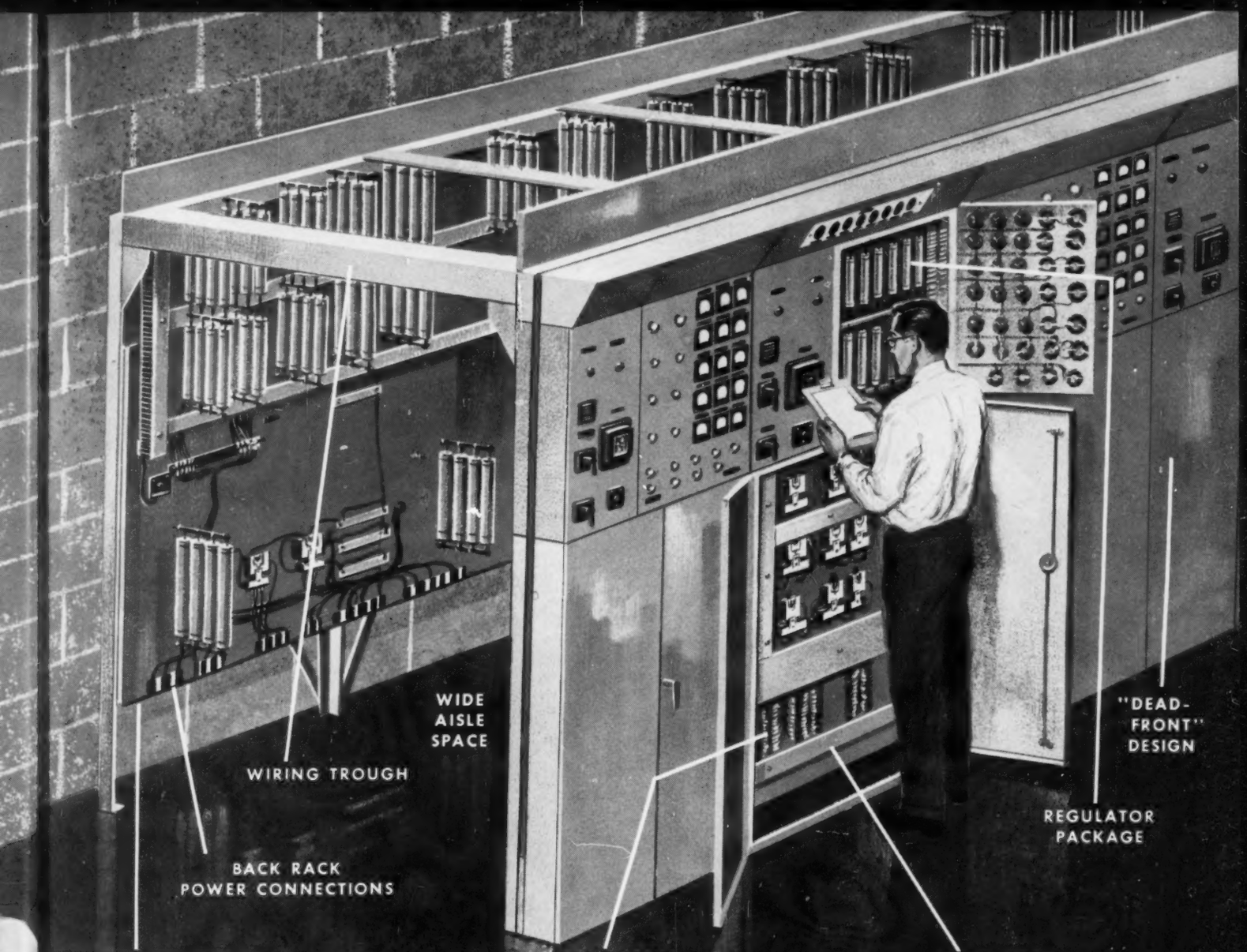
New control panels cut connection

General Electric has redesigned its industry-proved, heavy-duty, steel mill control panels—adding features to permit greater utilization of mill space . . . to save you time and money in installation and maintenance . . . and increase safety for operating personnel. The following cost-cutting and work-saving benefits tell the story of these new panels:

Reduced floor space—Compact design of this new panel cuts floor space needs up to 35 percent. More efficient arrangement of components provides added room for work inside the panel, yet reduces panel length. All incoming wires for control terminate at the front of the panel. All power wiring, including customer power connections, is isolated on the back rack. Use of welded studs and cage nuts permits installation against a wall —no need for additional work space behind panel. This saving in space means that valuable floor area can be used for other purposes, or construction costs of new buildings can be reduced.

Easier field connections—Installation wiring time is reduced as much as 50 percent by improved wiring layout. All incoming control wiring is brought to the front of the panel. A horizontal wire trough is available to the contractor to facilitate wiring to proper terminals and eliminate cord-tying bundles of wires in the field. Doors on the front of the panel open for access to terminal boards. For quick identification, terminal designations are permanently ingrained on the terminal board and into high-quality, plastic sleeves on each wire end.

Simplifed maintenance—Wide aisle between front panel and back rack makes maintenance easier and safer. Devices on front panel and back rack are connected *from the maintenance aisle,* allowing work from only



time 50%, required floor space 35%

one location. On the regulator package, fine-tuning adjustments are easier since potentiometers are located next to their related meters.

Increased safety—Since power wiring and all field power connections are isolated on the back rack, operating personnel are protected from accidental contact with high voltage. "Dead-front" construction, utilizing regulator packages and front panel devices behind doors, affords additional protection.

Improved appearance—All-steel bases provide rugged construction and uniform panel shape. Packaging of equipment into functional components and placement of contactors and relays behind doors give straight-line, modern appearance to panels.

For details on these steel-mill control panels, see your G-E Sales Engineer. Or write Sect. 785-13, General Electric Co., Schenectady, N. Y. for Bulletin GEA-6701. *Industry Control Dept., Salem, Va.*

Progress Is Our Most Important Product

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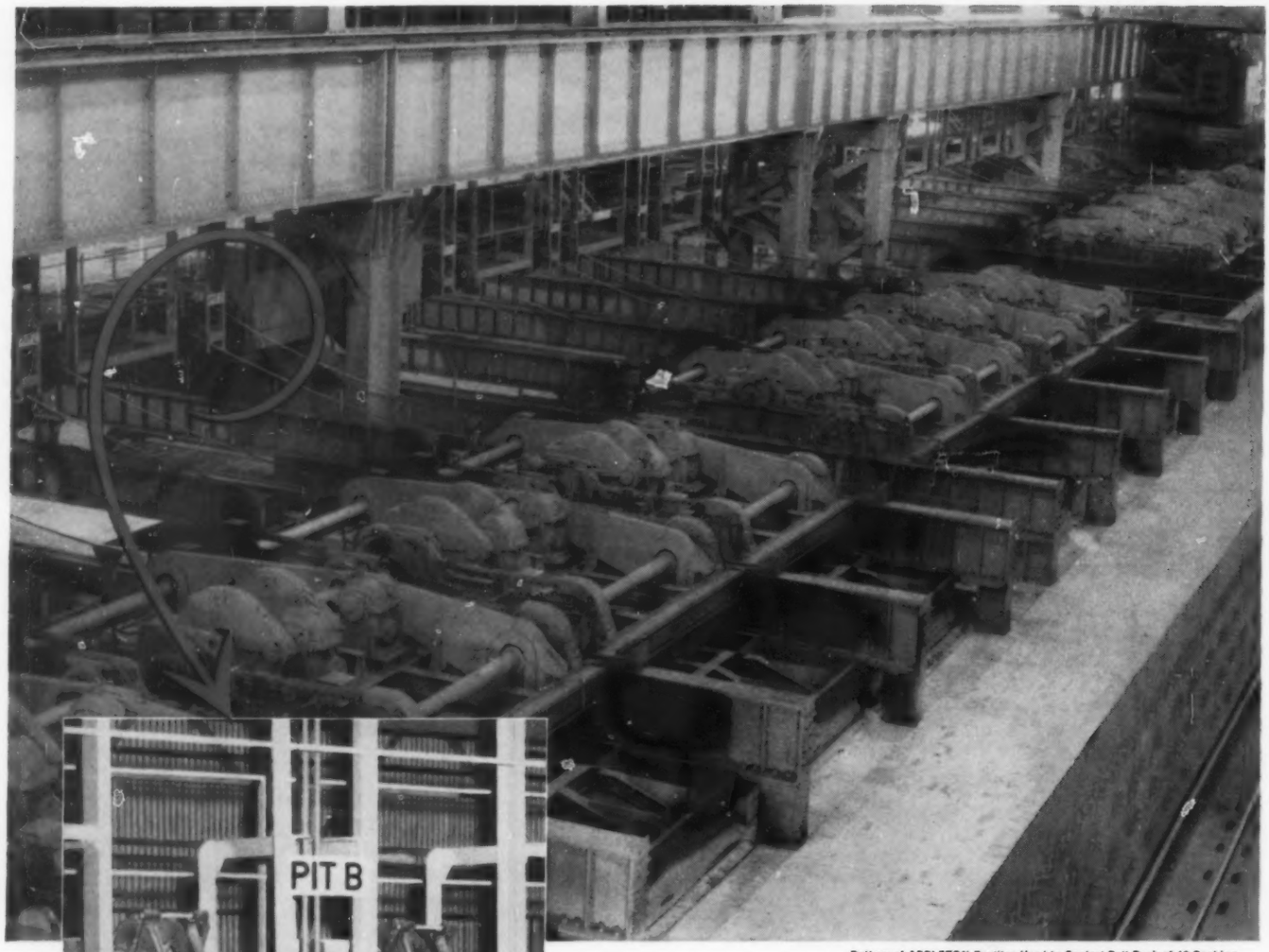

Battery of APPLETON Reelites Used to Control Roll Back of 48 Soaking Pit Covers at Largest Installation of Soaking Pits Ever Built at One Time.

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Industry looks to APPLETON for the finest in reels . . . to pay out or retract electrical cables with unfailing precision, safety and ease of handling.

There's an APPLETON *Reelite* for practically every industrial need. Made to APPLETON-engineered standards of durability and trouble-free operation, APPLETON *Reelites* can be used individually or banked for anything from light manufacturing production lines to the heaviest industrial applications.

Next time you plan an installation that requires handling of electrical cable, specify APPLETON. Write for Bulletin 505 for details on all models.

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Cable Take-Up

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Handy Listing Found in
Sweet's Plant Engineering File, Page 3C/AP

• Motor or Spring Driven • Explosion-Proof
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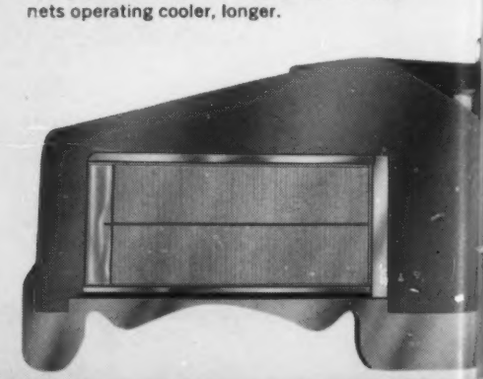
Two-compartment terminal box with lip on cover fitting into recess which relieves strain on hold-down bolts due to side blows.

3-point yoke design of cast steel keeps chains separate, prevents twisting and tangling.

Aluminum strapping on coils and special epoxy fill keep Cutler-Hammer lifting magnets operating cooler, longer.



Now! Lift all day long at high capacity with new Cutler-Hammer aluminum wound magnets

Lightweight aluminum strap coil keeps magnet cooler . . . adds to magnet life

Meet the magnets that never get tired, even on a sweltering summer day, the new Cutler-Hammer aluminum-wound lifting magnets.

With anodized aluminum strapping which eliminates insulation formerly required and a special epoxy fill designed to conduct off heat, the new Cutler-Hammer magnets operate cooler, give you more lifting capacity and last longer than copper-wound magnets.

Unlike the so-called "lightweight" magnets, there is no sacrifice in lifting capacity that results from fewer ampere turns to keep weight down. Completely watertight, these rugged magnets can safely be used for underwater service if given proper care and maintenance.

You can get the new Cutler-Hammer lifting magnets in four sizes: 39″, 45″, 55″ and 65″. Most sizes are available bolted or welded. Send for Pub. LO-108-A-232.

What's new at Cutler-Hammer?

New, better products, new plants, new engineering, new services are just part of the story at Cutler-Hammer. We're geared up to meet the tremendous demands of the next few years. We're ready to give you practical assistance in your growth plans for the future. Contact the nearest Cutler-Hammer sales office or your Cutler-Hammer distributor to see how.

WHAT'S NEW? ASK...

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MODERN ALL-WELDED STEEL MILL CRANES

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Crops and Shorts

△ Steel production in the United States ended 1960 with a dismal week of 39.4 per cent operating rate, the lowest nonstrike week in 22 years.

Actually, 1960 was not a bad year for steel, with a total ingot production of about 99,300,000 tons. Unfortunately, 60,754,095 tons were made in a record-breaking first half, leaving only about 38,500,000 tons for the last half.

The outlook for 1961 is cloudy. Some observers feel that it will be no better than 1960, but steel men expect it to be somewhat better, although none are predicting actual production. Some steel leaders' opinions:

Arthur B. Homer, chairman of Bethlehem Steel Co.: "I am confident that the level of Bethlehem's operations will start rising before very long and that we can look forward to a reasonably satisfactory year."

Harleston R. Wood, president of Alan Wood Steel Co.: "It is our feeling that all producers are faced with several months of continued low production, but we do believe that an upturn is in the air; if not immediately in sight. To be more specific, we believe that the steel industry should return to 'normal' conditions, or an operating rate of from 75 to 80 per cent of rated capacity, by late spring or early summer.

Roger M. Blough, chairman of United States Steel Corp.: "Prospects ahead, therefore, for the steel industry appear better than they have been for some time."

Thomas F. Patton, president of Republic Steel Corp.: "We foresee a moderate improvement in steel operations in the first and second quarters of 1961, with the year ending on an upward trend."

Joel Hunter, president of Crucible Steel Co. of America: "Since mid-1960 steel consumers have been reducing their inventories to bring them in line with the shorter lead time now available on steel delivery. When this adjustment process is completed—probably sometime during the first half of 1961—steel demand will recover to a more normal level."

Joseph L. Block, chairman of Inland Steel Co.: "It would seem to me that we could reasonably expect production of about 42,000,000 ingot tons in the first half of 1961 . . . I am hopeful that steel operations in the second half of 1961 will show a marked improvement over the first half."

△ Slow operations, combined with the expanded capacity of the industry, have again caused the industry to become self-conscious about its operating rate. The American Iron and Steel Institute will stop issuing the familiar percentage of capacity figure. This same move was attempted in 1958, when steel operating rates were around 50 per cent. At that time, an operating ratio that meant little to anyone was emphasized. A similar ratio may be incorporated in future reports.

The operating percentage, which was revived, is used by many business organizations in gaging their own performance, particularly between the various producing districts. There will be pressure to revive the figure again.

△ The trouble with most New Year's resolutions is they're either too hard to keep or too easy to break.

△ An American company is rumored to be considering participation in the erection of an integrated steel plant near the coast of Belgium. The plant would feature flat-rolled products. Participants in the project would include Arbed, of Luxembourg, Cockerill-Ougree, of Belgium, and Schneider (Le-Creusot), of France.

△ A machine that literally shreds scrap steel into small pieces for furnace charging is gaining acceptance. One unit has been in operation in Houston for well over a year. Another was installed in Kansas City and a third has been projected on the Pacific Coast. At least three similar units have been ordered.

△ Sleep is one of mankind's greatest blessings. It keeps many people from complaining 24 hours a day.

△ Some European steel plants are beginning to feel the effects of our recession, with production dropping off 10 to 15 per cent.

△ From *Powerfax:*

The Frenchman loves his native wine,
  The German loves his beer.
The Englishman loves 'alf and 'alf
  Because it brings good cheer.
The Russian loves his vodka straight
  Because it gives him dizziness.
The American has no choice at all,
  So he drinks the whole damned business.

△ A recent survey by the Professional Engineers Conference Board for Industry showed:

One out of four engineers in industry believes that engineers are thought of as second-class professionals, but no industrial managers agree with this opinion.

Sixty-one per cent of the engineers in industry think there is poor utilization of engineers, but only 30 per cent of industrial managers agree.

More than half of the engineers in industry think that higher pay would advance the engineering profession, but only 20 per cent of industrial managers agree.

△ Modern improvements: Narrow roads where two cars could barely pass are being replaced by wide freeways on which six or eight cars can collide at the same time.

△ We've just heard of a new kind of Christmas club. You save up enough money to pay for last Christmas gifts.

budway

Did you know there is a guaranteed way to clean stack gases?

Cleaning your gases is not a simple task. A careful analysis must be made of flue gas temperature, dust composition, and such things as dust loadings and gas volume. It takes a real crew of experts to make sense out of the data, then design, manufacture, and install equipment with *guaranteed* gas-cleaning efficiency.

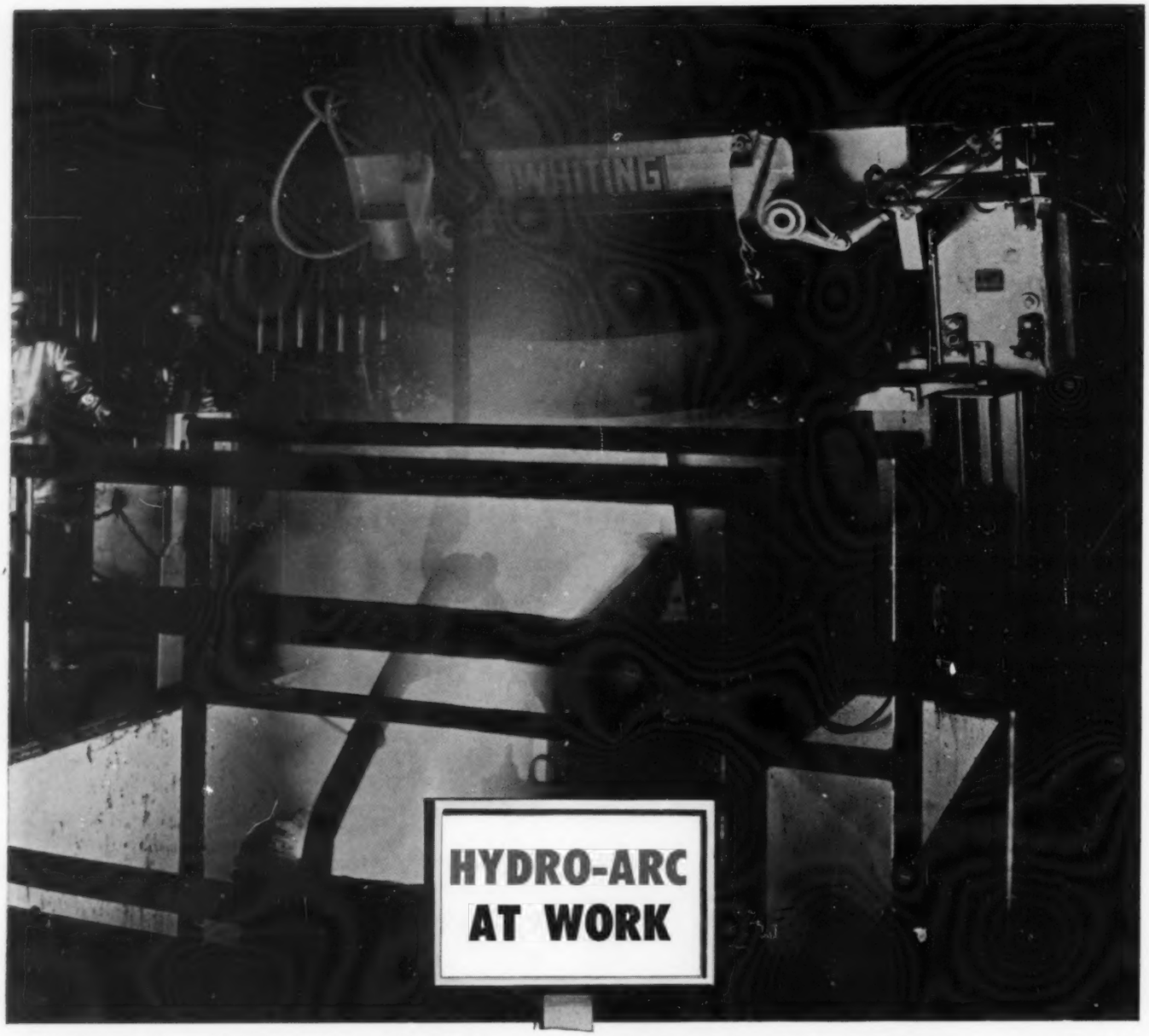
Koppers has over 50 years of industrial gas-cleaning experience. They're experts. Koppers designed and installed the first successful electrostatic precipitators for hot metal open hearth furnaces.

Two Koppers divisions work cooperatively to provide effective gas-cleaning installations. The Engineering and Construction Division can design and install a gas-cleaning system which will eliminate fumes, acid mist, ashes, or dust, as well as recover valuable materials at low cost per cubic foot of gas processed. Precipitators made by the Metal Products Division can be used with any steelmaking or ironmaking furnace, and they operate at close to 100% efficiency, with very little maintenance required.

Two outstanding examples of Koppers installations are the open hearth furnaces at Fairless Works of United States Steel Corporation, and the blast furnaces at Great Lakes Steel Division of National Steel Corporation. A completely different system was designed and installed by Koppers for the McLouth Steel Corporation. Here, they used pressure-type disintegrators to clean gases from electric furnaces and new oxygen converters. It proved efficient for both steelmaking processes. And Koppers is now installing seven additional electrostatic precipitators and ten additional waste heat boilers to control the gas discharge from open hearth furnaces at the Pittsburgh Works of Jones & Laughlin Steel Corporation.

Koppers will be glad to analyze your operation, too. Write to Koppers Company, Inc., Engineering and Construction Division, Pittsburgh 19, Pennsylvania.

KOPPERS® ENGINEERING and CONSTRUCTION

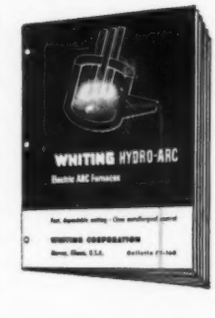


ASSURING PRECISE CONTROL IN PRODUCING SPECIAL ALLOYS

The H. M. Harper Company of Morton Grove, Illinois, manufactures extruded shapes and fasteners from their own special alloys of stainless, non-ferrous and carbon steel. To produce these quality alloys, Harper metallurgists specified this Whiting Hydro-Arc electric furnace.

Hydro-Arc assures complete control of the heat as self-adjusting electrodes automatically seek—and maintain—the precise arc level for maximum efficiency. This full-time arc action means cleaner heats at less consumption, with virtually no electrode breakage. Harper gets exactly the alloys desired, at predictable cost and significant savings.

Learn how Hydro-Arc can lower *your* melting costs while increasing production quality. See your Whiting Furnace Engineer, or write for Hydro-Arc Catalog FY-168. *Whiting Corporation, 15655 Lathrop Avenue, Harvey, Illinois. In Canada: Whiting Corporation (Canada) Ltd., 350 Alexander Street, Welland, Ontario, Canada.*



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From its very concept the RCA 110 was designed not as a "package" but as a total system—which can be tailored to the exact data control needs of each user. In making your feasibility studies we invite comparison with all other electronic industrial computer systems.

For complete information write: Industrial Computer Systems Dept., Electronic Data Processing Division, RADIO CORPORATION OF AMERICA, 21 Strathmore Road, Natick, Mass.

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ENGINEERED AIR (by AAF) keeps it clean!

● This intricate control panel at Jones & Laughlin Steel Corporation's Cleveland Works typifies the importance J&L places on the operation of its electrical equipment. Typical, too, was their insistence on the *right* kind of protection against dust damage.

J&L installed *five different types* of AAF filters to meet the differing clean-air needs of equipment serving its open hearth shop, blooming mill, finishing division and sintering plant. Result: at each filter installation, J&L has the *air cleaning efficiency it needs* plus *the maintenance characteristics it wants.*

To make sure you get clean air that's engineered for *your* specific needs, talk with the *one* company that makes *all kinds* of air filters—AAF. For more information, call your local AAF representative or write us direct. Address: Mr. Robert Moore, American Air Filter Company, Inc., 302 Central Avenue, Louisville, Ky.

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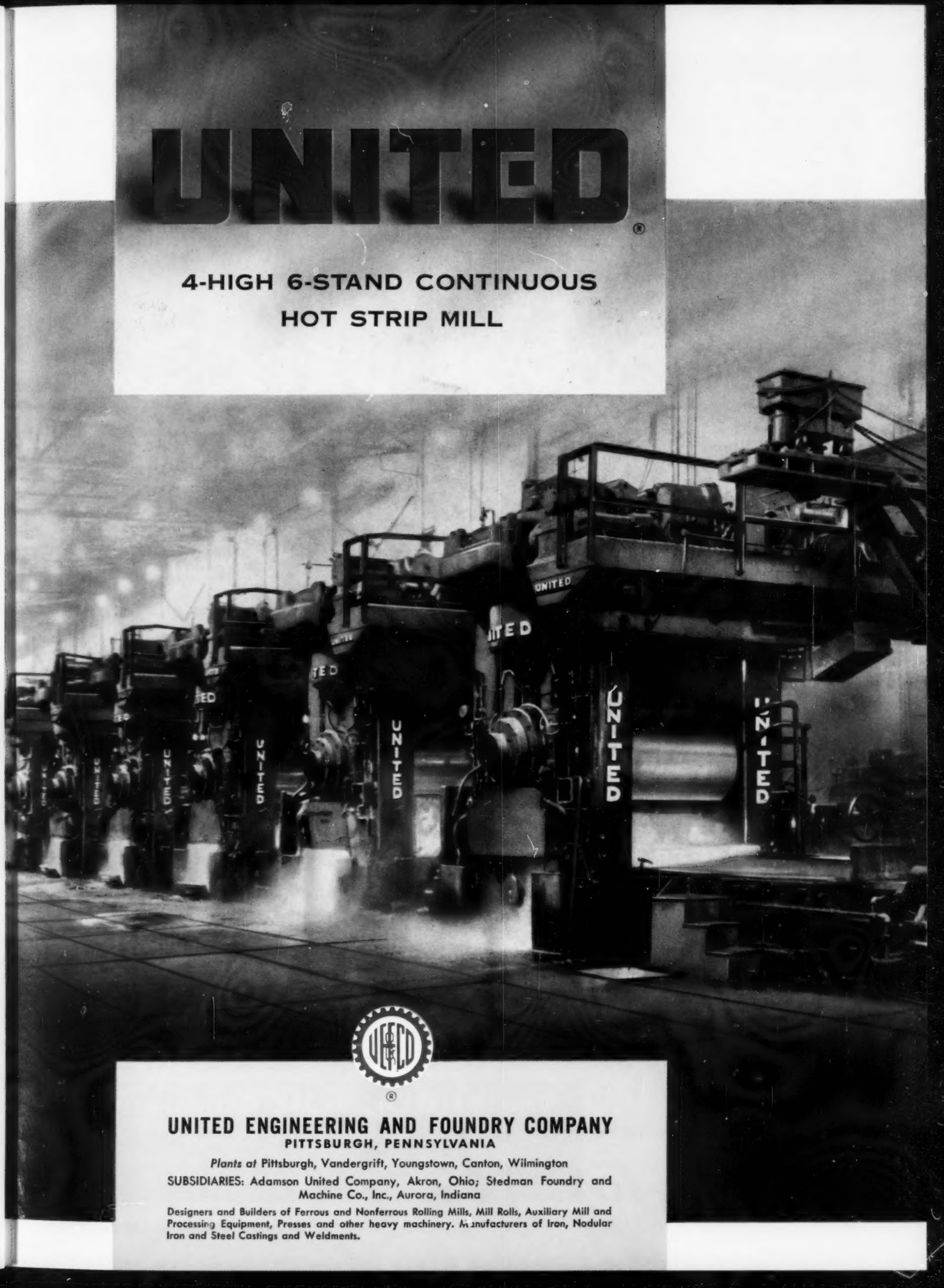
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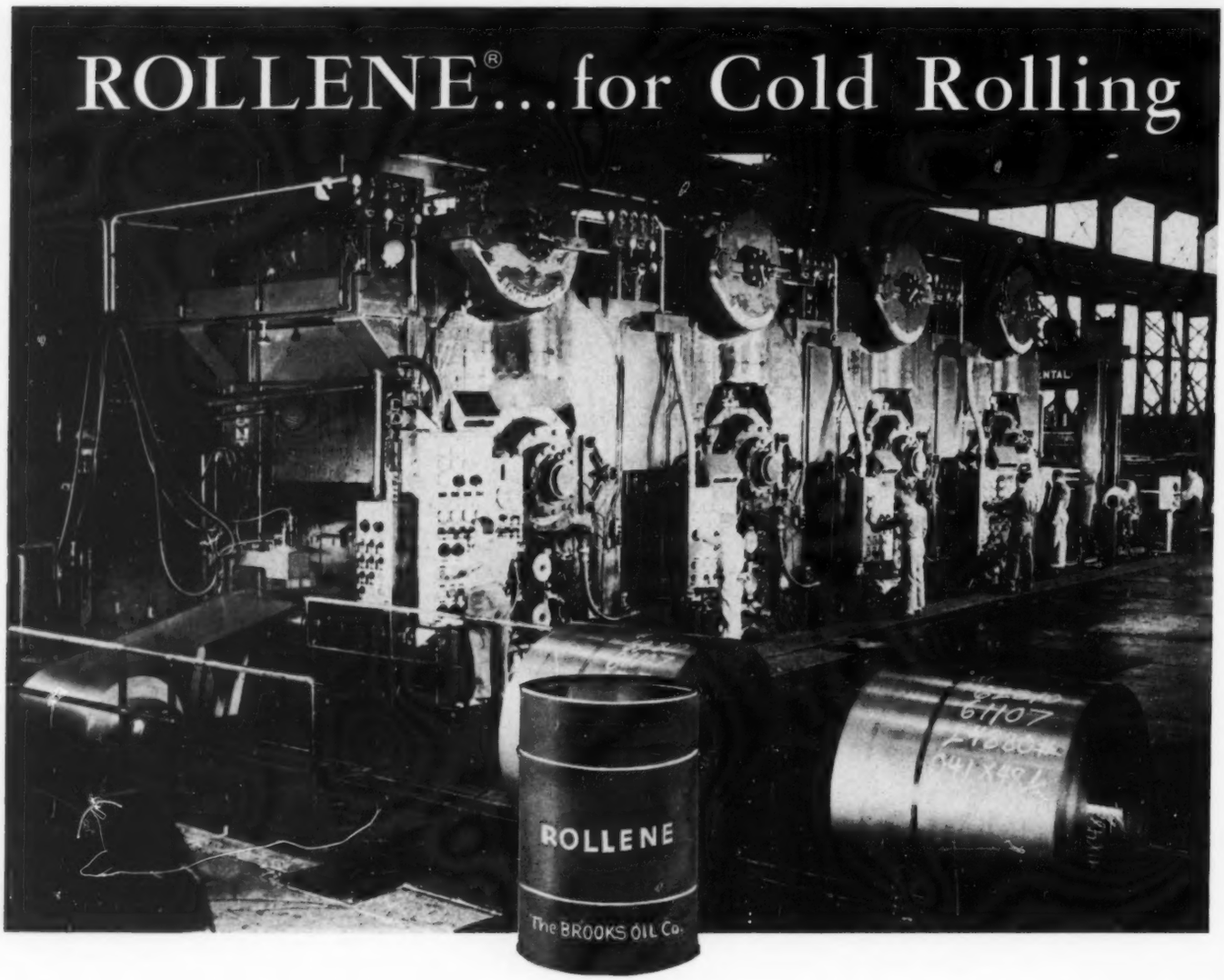

Products especially compounded for use in cold rolling of metal ranging from carbon steel to alloy steels, aluminum and other non-ferrous metals.

These compounds are applicable to mill and pickling operation either neat or cut back as the job requires. They can be mixed with water, forming an emulsion of low percentage for use in recirculating systems.

Rollene products are compounded to be used as breakdown oils for sheet and foil rolling of the aluminum industry.

There is a Rollene product for virtually every cold rolling service — which has proven that it will permit greater reductions, give better finish and require less cleaning. To obtain the optimum in cold rolling of metal, see the Brooks Oil man near you.

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T. R. Corn, Sales Engineer, Akron District Office.

This is Tom Corn, a Reliance Sales Engineer. Use this man the way he can be used, and you'll be buying not only good products, but a trained insight into the problems of applying electric motors and drive systems to products and processes, such as . . . . . .

RELIANCE ELECTRIC AND ENGINEERING COMPANY

Reliance meets the peculiar needs of progress.

Loading or unloading of United Jet Mainliner passengers in three minutes is now an accomplished fact at major air terminals.

Product of the jet age, this "Jetway" passenger loader came to life as a result of some unique engineering on the part of Reliance and the Pacific Iron and Steel Co.

Reliance engineered a drive system that makes the "Jetway" as easy to handle as an automobile. One operator moves it into position against the plane doors in less than a minute. Operation is smooth and stepless. Separate controls compensate for weight changes as the load shifts from plane to ramp and vice versa.

Adapting Reliance products to this unusual vehicle called for imagination and ingenuity . . . and the "Jetway" works fine.

The "Jetway" ramp now is used by several major airlines, and is operated by Reliance gearmotors, electronic exciters and motor-generator sets which convert airport a-c. power to d-c. More "Jetway" ramps are being installed at important terminals throughout the country.

RELIANCE ELECTRIC AND ENGINEERING COMPANY

Something more than electricity keeps this Reliance Motor running.

The oil field motor that drives this unit is protected, inside and out. It is not affected by dust, dirt, water or changes in the weather.

Reliance engineered and built this weather-proof motor, which is operating an oil well pump, in order to provide continuous operation with negligible maintenance . . . otherwise it wouldn't be where it is.

There are many such areas in the country where Duty Master Motors are subject to extreme environmental conditions. Yet the weather-proof is only one of a broad line developed to meet any a-c. motor requirement . . . and that takes in a lot of territory. Duty Master's wide acceptance is testimony to the creative engineering which produced it.

This 15 hp. Duty Master operates an oil well pumping unit at the Fair-Glenn Field, Sapulpa, Oklahoma. Sound insulation, rodent screens and the "Metermatic" lubrication system are vital qualities of this motor which performs so well in areas where weather and infrequent supervision are factors. It runs 24 hours a day regardless of adverse conditions.

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It takes more than horsepower to make a quality product.

These two super-calendar machines put a rich, glossy finish on paper. Alternate steel and cotton rolls produce a buffing, or polishing action on the previously treated product. Reliance Drives keep speeds of various rolls exactly regulated so that uniform, precise tension is maintained.

The big design trick here is to maintain exact tension during acceleration and deceleration of the drive system. Process requirements call for frequent speed changes. Any variation of tension during these changes is dangerous. The paper "web" can break, rolls can jam, the system can go haywire. But this one doesn't.

Reliance Engineers were in on this installation from start to finish . . . worked with company engineers to assure sound operation.

Tachometer feed-back systems with Reliance regulators keep the system perfectly controlled. Motors are synchronized to keep paper flowing smoothly at 2,000 feet per minute. A total of six machines in this mill are powered and controlled by Reliance, testimony to creative engineering and intelligent application.

Reliance Sales Engineers are ready to help your company solve motor and drive application problems . . . and they will act quickly and efficiently. There is a Reliance office near you. Check your telephone Yellow Pages . . . write, or call us direct.

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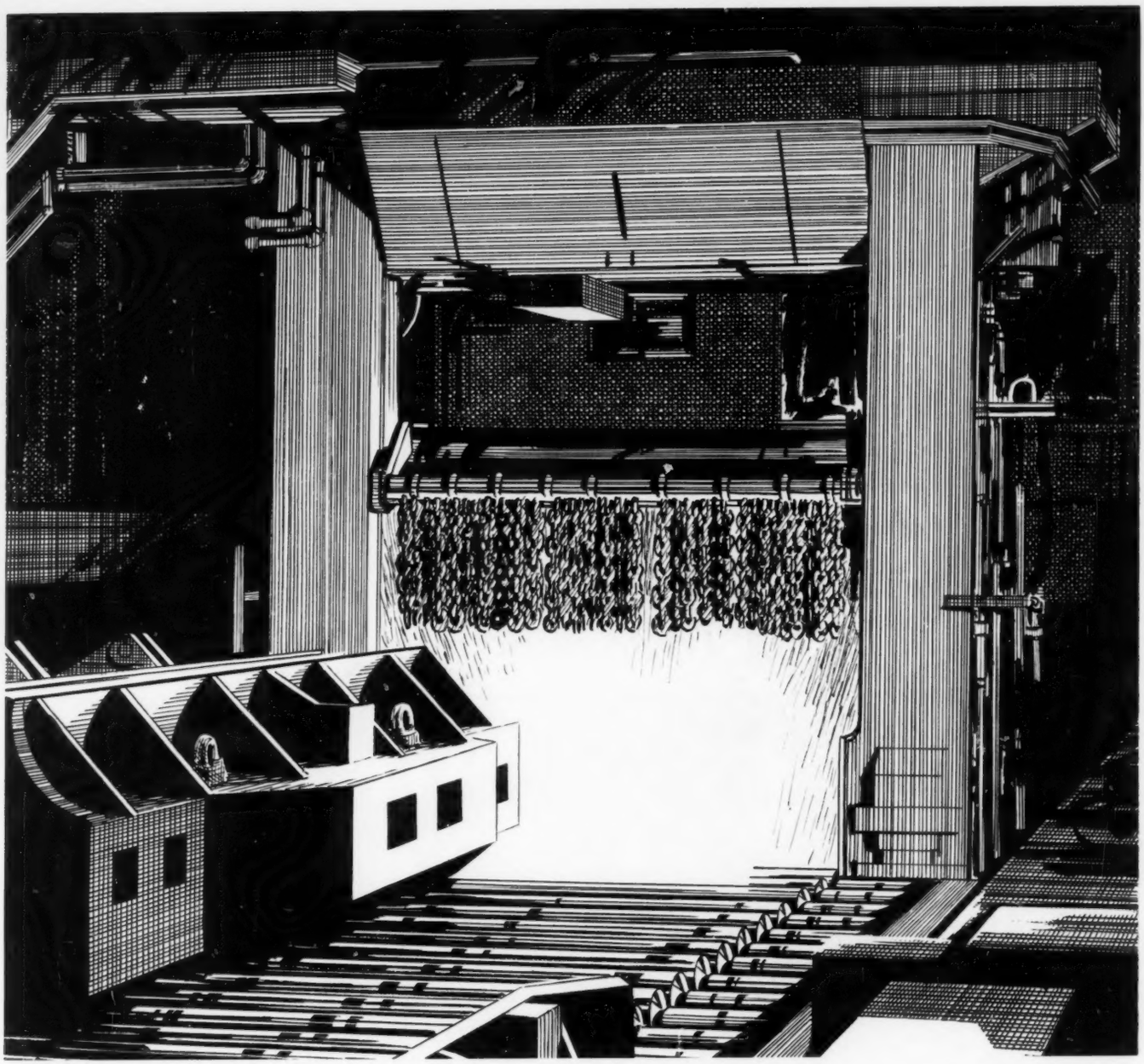

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Everywhere in the steel industry, the investment and cost stakes are high. For example, mill table rollers *must* provide maximum load-carrying capacity and resistance to shock loads . . . while permitting the roller to expand laterally under high heat.

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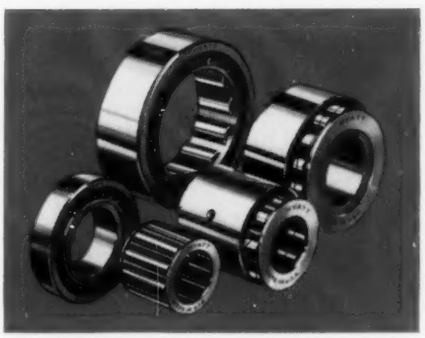
Call on a Hyatt Sales Engineer to show you the best possible relationship between maximum design conditions and proven service life for the tables in your mills. Hyatt Bearings Division, General Motors Corporation, Harrison, N. J.; Pittsburgh; Detroit; Chicago; Oakland, California.



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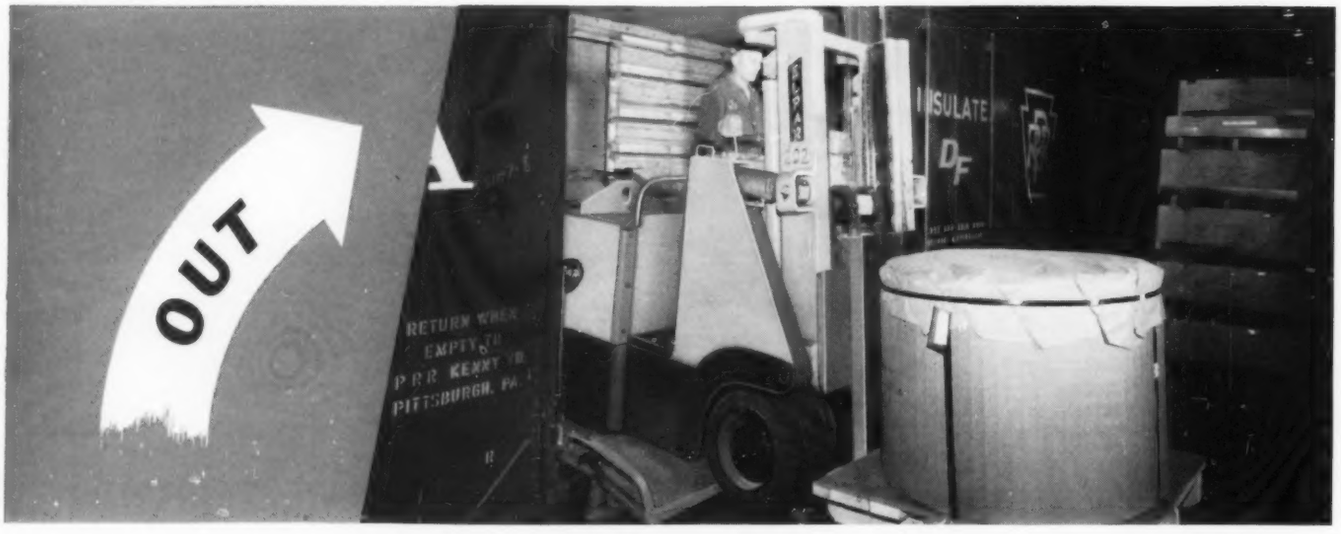

Handles 15,000 to 20,000 pound coils ...will operate in box cars, narrow aisles and congested areas.

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The Titan also establishes a new standard for dependability and easy maintenance that is unmatched by other trucks in the heavy duty class. You'll find a host of new safety features too.

There are four standard models—15,000 to 20,000 pound capacity—each one engineered to handle heavy loads faster and at lower cost.

Write for this TITAN Series Brochure—contains complete design and operating data.

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TWICE THE LIFE...ONE THIRD THE OPERATING COST

patent reviews

By MELVIN NORD, Patent Attorney, Detroit, Mich.

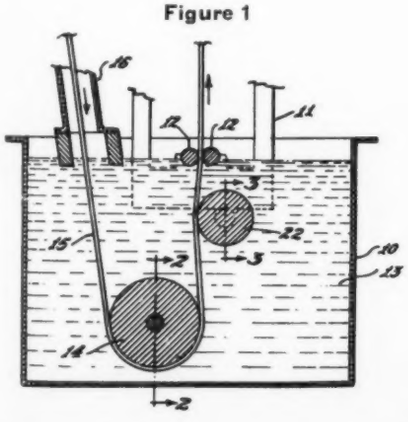
Copies of patents may be obtained from the Commissioner of Patents, Washington 25, D. C., at 25 cents . . . . patents reviewed cover period August 9, 1960 to September 6, 1960.

METHOD FOR IMPROVING METALLIC COATINGS

△ U. S. 2,950,215, issued Aug. 23, 1960 to Joseph C. Slater and Edward W. Platt, assigned to Armco Steel Corp., describes a method and apparatus for insuring the uniform and even coating of a metallic strip when it is fed through a pot containing molten coating metal. The object of the invention is to remove the scum which is normally picked up by the strip, so that an even and continuous coating is provided.

In Figure 1, a metal coating pot 10 is shown, provided with an exit machine 11 which includes exit rolls 12 between which the strip passes as it emerges from the body of molten coating metal 13. The strip 15 enters through duct 16 and then passes around the pot roll 14, to make certain that the strip passes well under the surface of the molten metal. Pot roll 14 is prevented from rotating by means of a gear (not shown). Thus, the strip in passing around the pot roll 14 is wiped on the side which is in contact with it. Another wiper roll 22 wipes the other face of the strip.

Figure 1



MECHANISM FOR CLASSIFYING METAL SHEETS

△ U. S. 2,950,640, issued Aug. 30, 1960 to James B. Camp and assigned to United States Steel Corp., describes a method for classifying and assorting metal sheets in high speed shear lines.

Figure 2 shows a shear line consisting of a roller leveler 1, a rotary flying shear 2, a conveyor 3, a prime sheet piler 4, and a reject sheet piler 5. Strip S enters from the left from an uncoiler, and passes through the roller leveler and the shear. The latter cuts it into sheets S′, which are deposited on the conveyor and travel to the pilers. A deflector is interposed between the exit end of the conveyor and the pilers. Normally this deflector allows prime sheets to pass undisturbed to the prime piler, but it can be operated by detecting means and time delay means to divert imperfect sheets to the reject piler.

The deflector consists of a fixed blade 7 and a normally magnetized roll 8 driven at the same speed as the

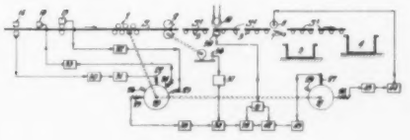


Figure 2

speed of the conveyor 3. As long as the roll is magnetized, it carries sheets discharging from the conveyor across the blade to the prime piler 4. When demagnetized, the roll allows sheets from the conveyor to pass underneath the blade to the reject piler 5.

TOP BLOWING OF LIME AND OXYGEN INTO IRON

△ U. S. 2,950,186, issued Aug. 23, 1960 to Marc Allard, Bernard Trentini and Lucien Wahl, assigned to Institut de Recherches de la Siderurgie, describes a method for top blowing pulverulent burnt lime and oxygen into pig iron for refining it. The process is particularly advantageous in the case of pig irons containing as much as two per cent phosphorus.

A jet of oxygen and lime of a high penetrating capacity is formed which has a momentum which is very large and is concentrated in the vicinity of the axis of the jet blown over the bath.

The apparatus is shown in Figure 3.

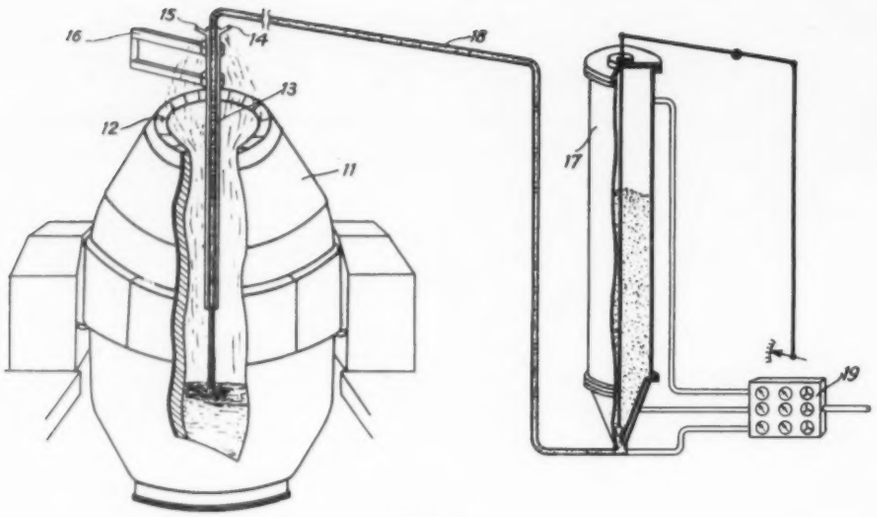


Figure 3

PROCESS OF MAKING LADLE STOPPER HEADS

△ U. S. 2,949,637, issued Aug. 23, 1960 to Michael O. Holowaty and Albert M. Kroner, assigned to Inland Steel Co., provides a method of making ladle stopper heads which avoid the formation of peripheral cracks.

It has now been discovered that stopper heads of excellent properties and normally devoid of peripheral cracks can be produced by maintaining the water content at 8 per cent or less by weight in the clay-graphite aqueous mixture prior to pressing into a "green" stopped head, pressing the mixture into a stopped head, water vapor curing the head and then drying and burning the stopper head.

The process is shown schematically in Figure 4.

CLEANING SOAKING PIT BURNER PORTS

△ U. S. 2,948,909, issued Aug. 16, 1960 to Edward W. Haeckler and assigned to United States Steel Corp., describes an apparatus for cleaning burner ports in bottom center-fired soaking pits. The tool employed is in the nature of a drill and reamer for removing accumulations of slag and cinder. Figure 5 shows a conventional arrangement of a burner port in a bottom center-fired soaking pit. It consists of a pit bottom 1 of coke-breeze on which ingots are supported during a heating operation, a refractory lined burner port 2 arranged centrally and extending vertically through the furnace bottom, and a burner pipe 3 arranged centrally and axially of the port 2 through which gaseous fuel is supplied to the furnace, the air required for combustion being supplied from an underlying air chamber through the annular space 4 between the external surface 5 of the pipe 3 and the internal surface 6 of the port 2. The refractory lining for the port 2 is provided by the bottom brickwork 7 and a monolithic body 8 which is contained in a steel form 9 supported on the brickwork 7.

During normal operation, accretions of slag and cinder form on the surfaces 5 and 6 and interfere with efficient soaking pit operation. Such accretions derive from molten slag overflowing from the furnace floor into the burner port 2 and from hot particles of cinder from the coke-breeze bottom 1 or scale from ingots falling and collecting on the surfaces 5 and 6. They collect mainly on the upper end portions of the facing surfaces 5 and 6 and may at times form an obstructing bridge between them. The apparatus for effecting their removal consists of a tool in the nature of a drill or trepan, designated as a whole by the numeral 11, and the tongs 12 of a conventional ingot crane, as shown in Figure 6.

JET SMELTING OF PARTICULATE ORES

△ U. S. 2,951,756, issued Sept. 6, 1960 to Patrick E. Cavanagh,

Figure 4

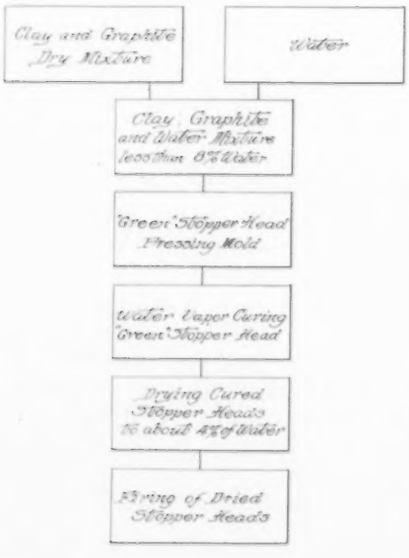
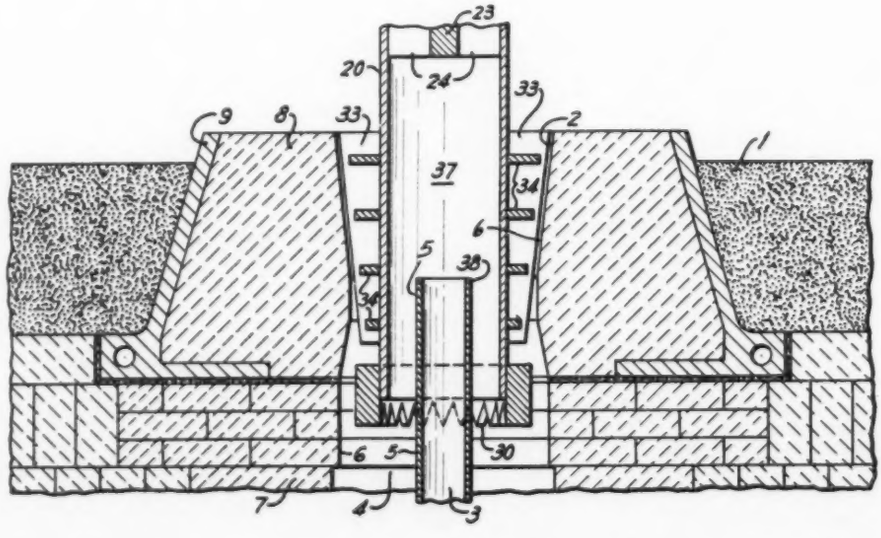
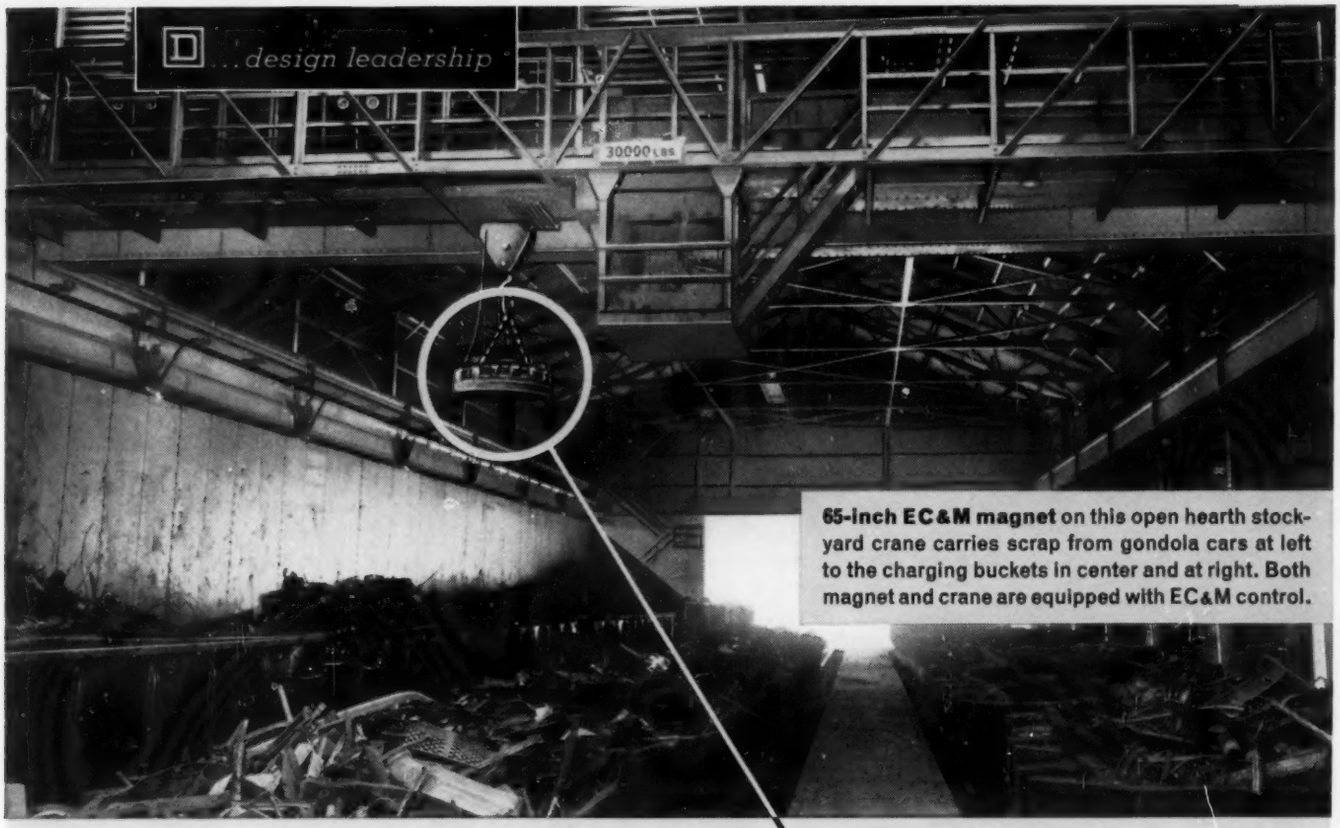

Clay and Graphite Dry Mixture
Water
Clay, Graphite and Water Mixture less than 8% Water
Green Stopper Head Pressing Mold
Water Vapor Curing Green Stopper Head
Drying Cured Stopper Heads to about 4% of Water
Firing of Dried Stopper Heads

Figure 5





65-inch EC&M magnet on this open hearth stockyard crane carries scrap from gondola cars at left to the charging buckets in center and at right. Both magnet and crane are equipped with EC&M control.

EC&M ALL-WELDED Magnets Give EXTRA Lifting Power

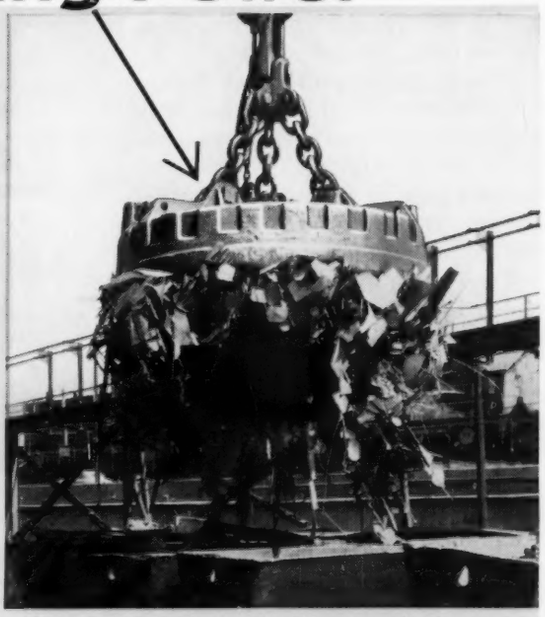
and Extra Lifting Power means Lower Handling Costs

• You get extra lift with EC&M all-welded construction. Because the pole shoes are welded in place, they fit more snugly — and they stay that way. Recesses for bolts are eliminated. The result — a more efficient magnetic path, with the entire face of the magnet effective for lifting.

EC&M welded magnets give you other advantages, too. The continuous weld makes them completely waterproof. They have greater impact-resistance, are better able to take the hard knocks of mill operation. If outer leads should be damaged, solderless connectors under protective covers simplify replacement.

EC&M lifting magnets are available in diameters from 39 to 80 inches. Magnets with bolted construction are also available when desired, as well as light-weight magnets for fast-moving mobile cranes. For any magnet, it makes sense to specify an EC&M controller.

Write for details! Bulletin 1300 gives information on the complete line of EC&M magnets and controllers



Close-up view shows EC&M magnet loading scrap into the charging buckets. The special low-carbon steel housing has high permeability, contributes to extra magnet efficiency.

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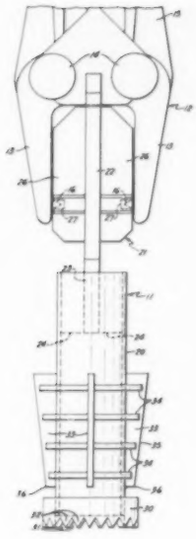


Figure 6

provides for the production of metallic iron from magnetite ores in finely divided particulate form, the ore particles being propelled in a flame during treating and injected into a furnace bath by impingement of the products of combustion upon the surface of the bath.

As shown in Figure 7, a supply of finely divided particulate ore of predominately magnetite is introduced into hopper 56. The ore is mixed with a suitable flux, preferably lime, to combine in the separation of gangue portions from the ore being treated.

The particulate ore and flux is fed downwardly through gas lock 57 and duct 55 into the mixing compartment 46. Oxygen is introduced through pipe 51 to mix with natural gas introduced through pipe 50 as the mobile fuel.

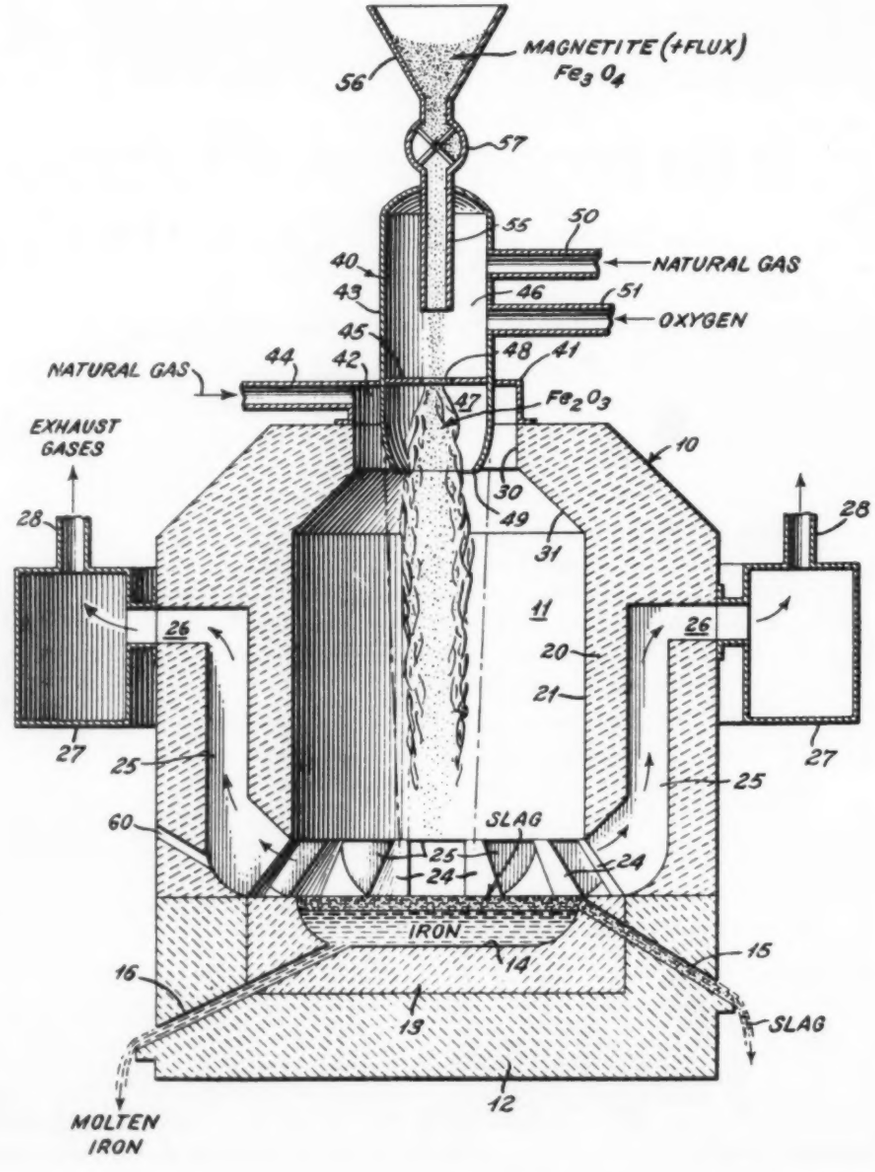
The mixture, including ore particles and flux, in passing from duct 55 through compartment 46, mixes with the combustible gases formed from the natural gas and oxygen and pass through the burner orifice 48.

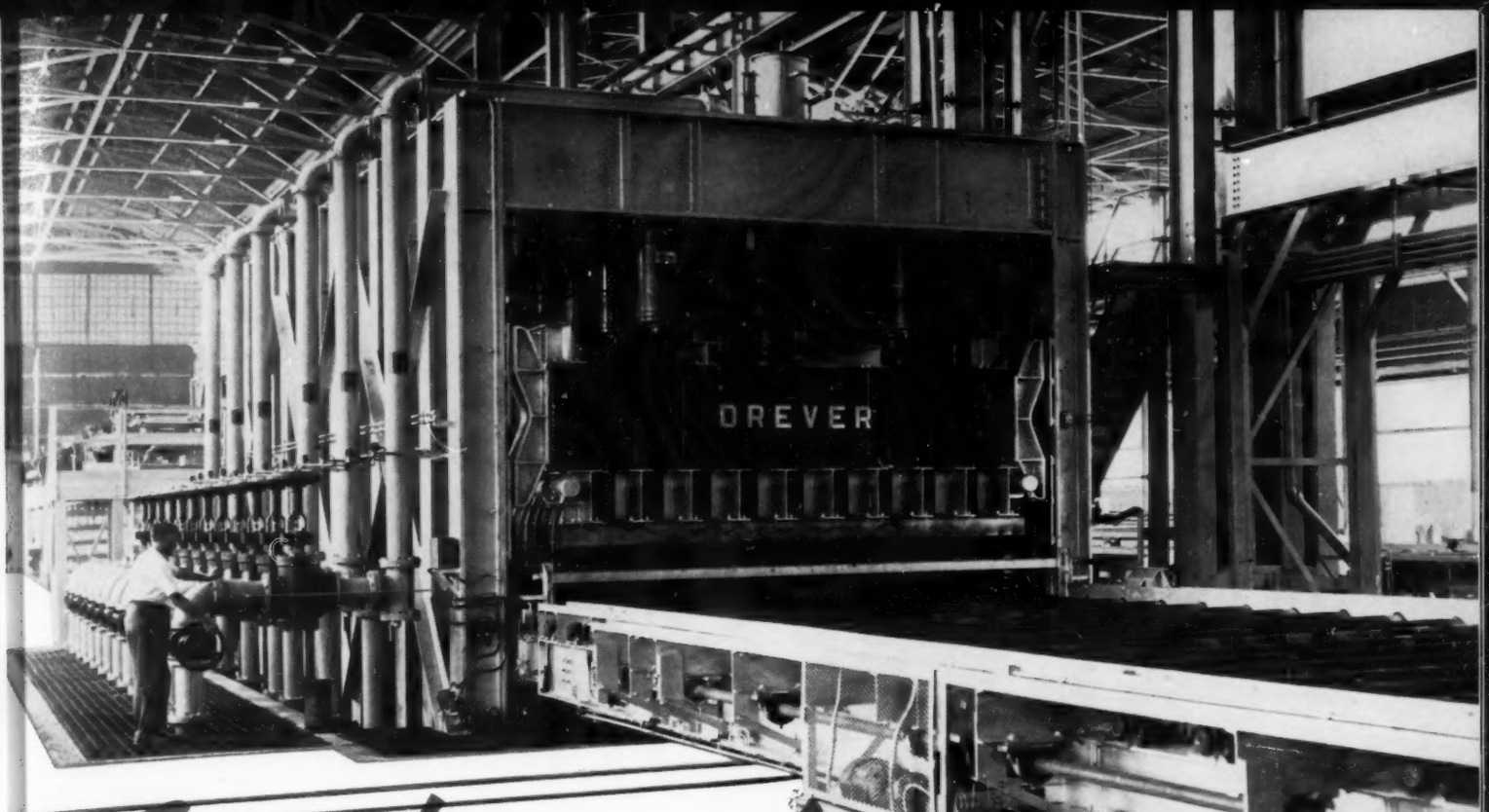
The combustible gases are ignited in reaction chamber 47. The flame temperature within this chamber is about 4200 to 4500 F and rapidly raises the temperature of the ore particles, with increase in temperature being aided by the reaction of the magnetite ore with the excess oxygen in the combustion products which oxidizes the ferrosoferric oxide to hematite or ferric oxide. This reaction is exothermic, with the heat given off by such reaction further contributing to the rapid temperature rise of the ore particles to about 3500 to 3600 F. Whereas the flame temperature in compartment 47 is preferably between about 4200 to 4500 F, it is pointed out that the temperature of the ore particles must be at least 2800 F for the reaction between the magnetite ore and excess oxygen to occur.

A particular advantage flowing from the extremely rapid heating of the ore particles results from the decrepitation and cracking of such particles occurring during this rapid heating. This shattering exposes substantially greater surface areas of the particles to the high temperature and excess oxygen in the flame, such that the entire quantity of the particles is brought up to the requisite temperature in a minimum time as the flame and particles pass downwardly from reaction chamber 47 through outlet 49. The gaseous combustion products leave the burner at about 4000 F.

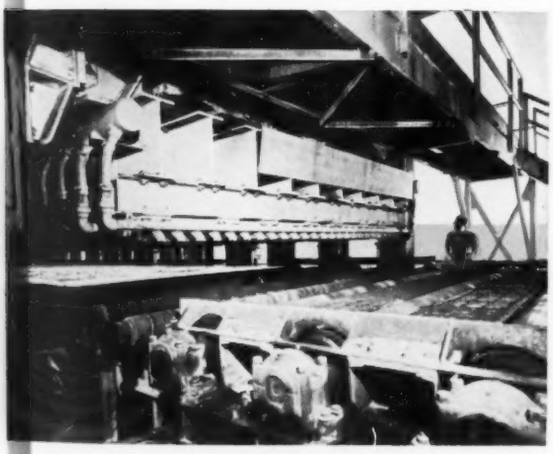
The gaseous combustion products and mixture suspended in them are propelled downwardly into reducing chamber 11. A supply of natural gas as a reducing agent is introduced through conduit 44 into annular chamber 42. This chamber surrounds the lower end of burner casing 43, and accordingly, the reducing agent is preheated by contact with the hot wall of the burner casing. The reducing agent, in the form of natural gas, flows downwardly through opening 30 into reducing chamber 11. In such downward flow it envelops the combustion products and mixture passing

Figure 7





Takes the wrench out of the quench!



AT TOP: 2,500 ton pressure quench using 24,000 gpm of water. For 172" wide x 3" thick maximum plate. Transfer car in foreground.

ABOVE: Plate at hardening temperature in pressure quench prior to closing the platens.

DREVER PRESSURE QUENCH KEEPS PLATE FLAT WHILE UNIFORMLY QUENCHING WITH THOUSANDS OF JET SPRAYS

While as many as 35,000 water sprays quick quench the steel plate, the Drever Quench holds it under pressures up to 2500 tons through the use of ribbed platens. The result? High uniformity of quench and a flat plate, and usually, the elimination of any further levelling operations.

PIONEERING ENGINEERING IN THE QUENCH OPERATION

As an important component of the Drever Plate Heat Treating Lines, Drever Quenches handle plate up to 172" wide x 3" thick and 45' long in fully automatic operation. Designed for versatile operation too, a wide variety of product mix can be quenched as well as plate from both the hardening and tempering furnaces.

DREVER ENGINEERING FOR YOU

Drever engineering has contributed to the advancement of production rates and quality standards in every phase of the heat treating process for both large and small operations. In furnace design, in associated processes, in handling equipment Drever engineering staff has a wealth of experience which can be applied to your requirements. Drever Company, Bethayres, Pa. Phone: WI 7-3400.

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"TRANTINYL" offers a quarter-century of metallurgical experience. "TRANTINYL" patented alloys were developed to function in specific operations where guides are required to resist wear and abrasion. Users of "TRANTINYL" alloys are astounded at the tonnage rolled over one set of guides.

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bar, hoop, strip, shape mill guides; and rollers.

SEAMLESS TUBE MILLS:
guide shoes, rolling mill plugs and rolls, piercer points, etc.

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STRAIGHTENING MACHINE GUIDES

HEAT RESISTING CASTINGS

"TRANTINYL No. 1" CAST TO SHAPE

Youngstown Alloy Casting Corporation

Youngstown, Ohio

through outlet 49 such that the two streams flow concurrently downwardly through reducing chamber 11. The added natural gas provides a reducing atmosphere to react with the ferric oxide in the suspended mixture to reduce it to metallic iron.

The gaseous constituents, slag and metallic iron are propelled downwardly, by operation of the downwardly directed burner assembly 40, toward the surface of the molten bath in cavity 14. The gaseous constituents are given sufficient momentum by the burner operation such that the metallic iron and slag will be injected into the bath, resisting the tendency of the gases to carry these materials laterally and upwardly through passages 25 as the gases are conducted from the furnace.

PRODUCTION OF GRAIN-ORIENTED INGOTS

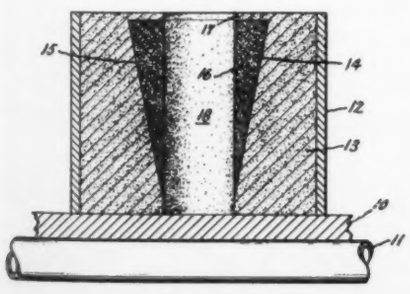
△ U. S. 2,951,272, issued Sept. 6, 1960 to Allan J. Kiesler and assigned to General Electric Co., describes a method and apparatus for producing iron-base alloy ingots consisting primarily of a number of elongated columnar as-cast grains whose longitudinal axes are parallel. The process does not require the application of external heat before or during the casting and solidification of the ingot.

As shown in Figure 8, the apparatus includes an upper base plate 10. Means for cooling plate 10 are provided by a conduit 11 in a heat exchange relationship with plate 10 and through which a coolant such as cold water may be circulated.

Supported upon plate 10 is a hollow, tubular flask 12. Foundry molding sand 13 is rammed into flask 12 about a pattern having a cross-sectional area which is greater at one end than at the other end, so that when it is removed a tapered cavity remains in the sand. As shown in Figure 8 this tapered cavity is defined by the straight lines 14 and 15. A second pattern is then placed in the cavity in the rammed foundry sand. This second pattern has substantially the dimensions and configuration of the desired ingot. One end of the second pattern has substantially the same cross-sectional area and configuration of the small end of the first pattern and closely fits the corresponding end of the cavity. The opposite end is usually geometrically similar in cross section to the first but at least slightly larger in area to provide sufficient "draught" for removal after the mold is complete. The tapered space between the walls of the tapered cavity in the rammed foundry sand and the substantially straight sides of the second pattern are rammed with a mold lining material 16 which is capable of giving off large quantities of heat by an exothermic reaction when contacted by molten metal. The tapered cavity may also be filled with a prerammed core. When the rammed exothermic material substantially fills the tapered space, an additional quantity of foundry sand may be rammed in place to form a cap-like structure over the exothermic material as shown at 17. The second pattern may then be removed, leaving a tubular mold cavity 18 as shown.

In practice it has been found that when molten-iron base alloys are cast into the mold cavity 18 directly upon the mold bottom plate 10 which is maintained at about room temperature during the pouring and solidification of the mold metal, that solidification begins at the cooled surface of the bottom 10. As the level of the molten metal rises in the mold, the exothermic lining material begins to react to produce large quantities of heat, a large portion of which is transferred to the molten metal to retard its loss of heat laterally into the sand portion of the mold. A large portion of the superheat and latent heat of the molten metal is thereby extracted through the mold bottom and solidification of the metal in the mold progressively occurs from the bottom to substantially the top of the ingot thus formed. Substantially all of the metal in the ingot with the exception of the very top "pipe" section of the ingot is composed of elongated columnar grains with their longitudinal axes substantially parallel and extending in a direction substantially parallel to the direction of heat extraction, i.e., from the top to the bottom of the mold cavity.

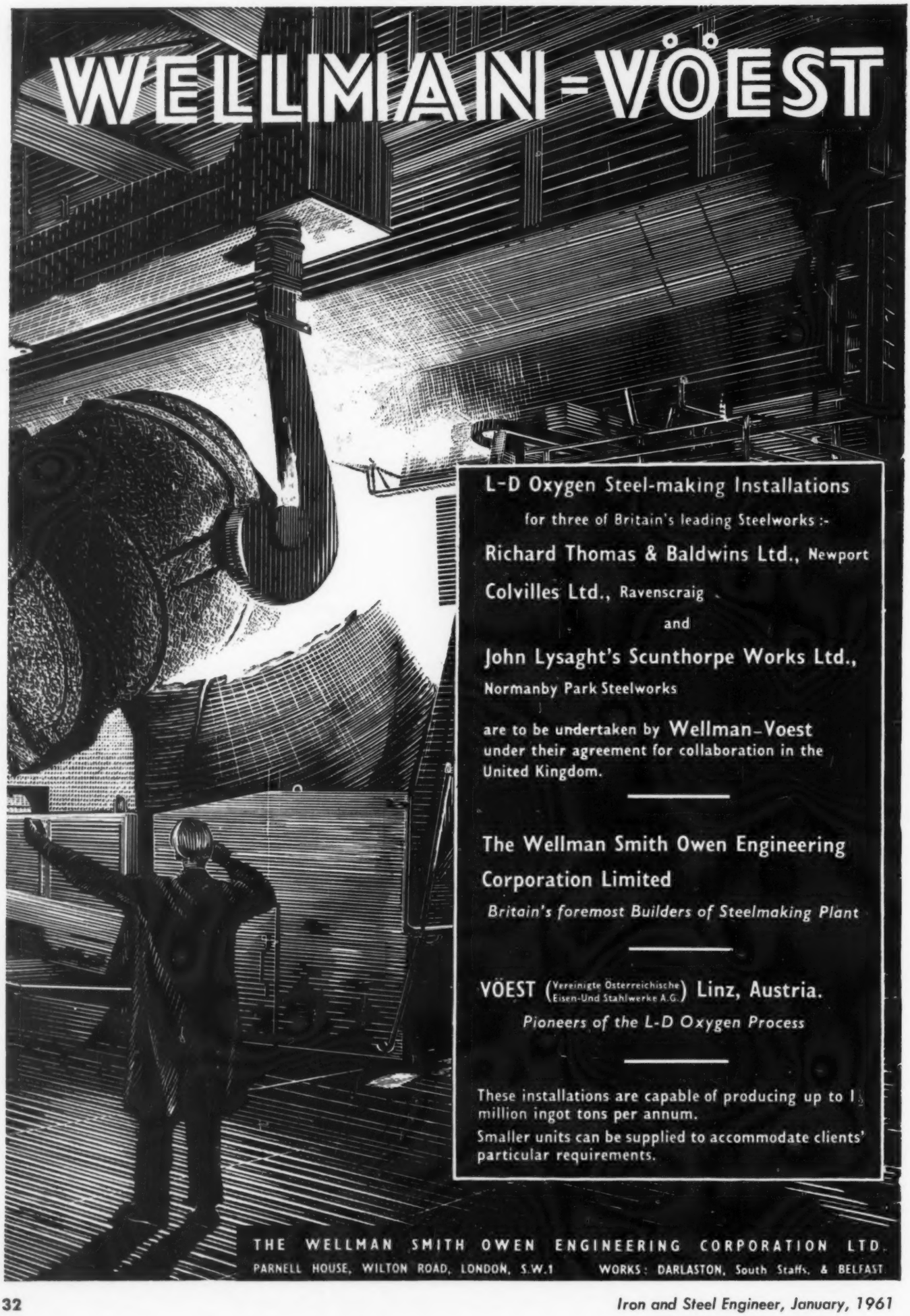
Figure 8



OTHER PATENTS OF INTEREST TO THE IRON AND STEEL ENGINEER

Patent No.	Date	Subject	Inventor or Assignee
2,948,030	8/ 9/60	Continuous casting of molten metal	Koppers Co., Inc.
2,948,603-4	8/ 9/60	Nickel-free austenitic high-temperature alloy	Allegheny Ludlum Steel Corp.
2,948,605	8/ 9/60	Nodular iron	Allis-Chalmers Mfg. Co.
2,949,289	8/16/60	Grate bar for sintering apparatus	Metallgesellschaft A. G.
2,949,355	8/16/60	High temperature alloy	Allegheny Ludlum Steel Corp.
2,949,356	8/16/60	Ferrous alloys for forming metals at high temperatures	Latrobe Steel Co.
2,949,430	8/16/60	Protection of carbon electrodes for electric furnaces	A/S Ardal og Sunndal Verk
2,949,634	8/23/60	Briquetting roll	United States Steel Corp.
2,950,094	8/23/60	Cooling arrangement for electric furnace	Republic Steel Corp.
2,950,097	8/23/60	Carbon-faced conveyor roll for silicon steel strip	United States Steel Corp.
2,950,150	8/23/60	Lubricated roll	United States Steel Corp.
2,950,187	8/23/60	Iron-calcium base alloy	The Research Institute for Iron, Steel & Other Metals of the Tohoku University
2,950,955	8/30/60	Preparation of finely divided ferromagnetic ferric oxide	Deutsche Gold -und Silber-Scheideanstalt
2,950,968	8/30/60	Deep-hardened alloy steel having improved impact strength	The Carpenter Steel Co.
2,951,657	9/ 6/60	Coiling apparatus	Hydrometals, Inc.
2,951,768	9/ 6/60	Chemical removal of zinc coating from iron	Mark P. Brash et al.

WELLMAN-VÖEST



L-D Oxygen Steel-making Installations

for three of Britain's leading Steelworks :-

Richard Thomas & Baldwins Ltd., Newport

Colvilles Ltd., Ravenscraig

and

John Lysaght's Scunthorpe Works Ltd.,

Normanby Park Steelworks

are to be undertaken by **Wellman-Voest** under their agreement for collaboration in the United Kingdom.

The Wellman Smith Owen Engineering Corporation Limited

Britain's foremost Builders of Steelmaking Plant

VÖEST (Vereinigte Österreichische Eisen-Und Stahlwerke A.G.) **Linz, Austria.**

Pioneers of the L-D Oxygen Process

These installations are capable of producing up to 1½ million ingot tons per annum.

Smaller units can be supplied to accommodate clients' particular requirements.

THE WELLMAN SMITH OWEN ENGINEERING CORPORATION LTD.

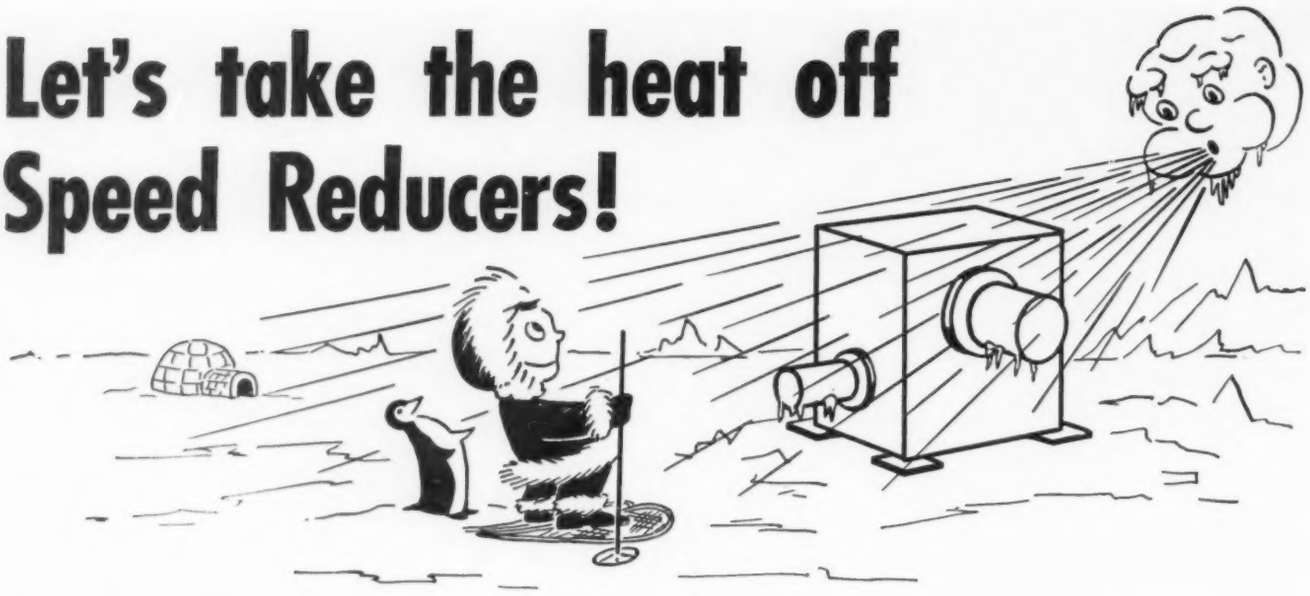
PARNELL HOUSE, WILTON ROAD, LONDON, S.W.1 WORKS: DARLASTON, South Staffs. & BELFAST

Weigh Molten Steel In Transit With ASEA's Pressductor

Save one big step with this new application of Asea's Pressductor. The Pressductor measures the accurate weight of molten steel or other crane suspended loads in transit. Gone is the non-productive, tedious–and frequently inaccurate—weighing stage. Here is how it works: mounted on the crane (and it can be easily installed), the Pressductor **A** senses the load, gives rise to a changing magnetic flux. This induces a voltage which is then read on a pointer–indicating instrument **C** a digital voltmeter **D** paper tape or a punched card recording unit **E**. The Pressductor can be connected to a device giving a signal when crane is overloaded **B**. The indicator can be placed in the operator's cabin or mounted on the crane, so that it can be seen from the ground. This is the very same compact Pressductor which is used in most rolling and strip mills to measure and register heavy roll pressures. It allows uninterrupted production, gives you accurate weighing, can supply a permanent record of every stage of your operation with a minimum of attention and maintenance. It does not involve any major change in your crane—and Asea will supervise the installation. For further information, full details, specifications, write to: ASEA ELECTRIC, INC., 500 Fifth Avenue, New York 36, N. Y., 55 New Montgomery Street, San Francisco, Calif.

ASEA

Let's take the heat off Speed Reducers!



A worm gear speed reducer is one of the toughest little customers in captivity. It reduces speeds day-in, day-out, with little complaint. While it works long and hard, it has limitations—set by ratio, center distance, RPM, mechanical and thermal HP ratings, etc. And, depending upon how precisely it was selected and fitted to the job requirements, it will do what it has to do.

But sometimes it's forced to play outside of its league. It must cope with job requirements that vary from here to there—normal 8 to 10 hour service without recurrent shock, the same length of service where there is some shock loading, continuous low-speed service and almost countless others. But the thing that really puts the pressure on reducers, the thing that's lurking in *every* set of job requirements—is h-e-a-t.

When you exceed the thermal capacity of a reducer for more than an hour or so, excessive temperature thins the lubricant resulting in wear; material, bearing and oil seal failures; etc. Of course, the proper lubricant will help but it can't cure the continuing problem of excessive heat.

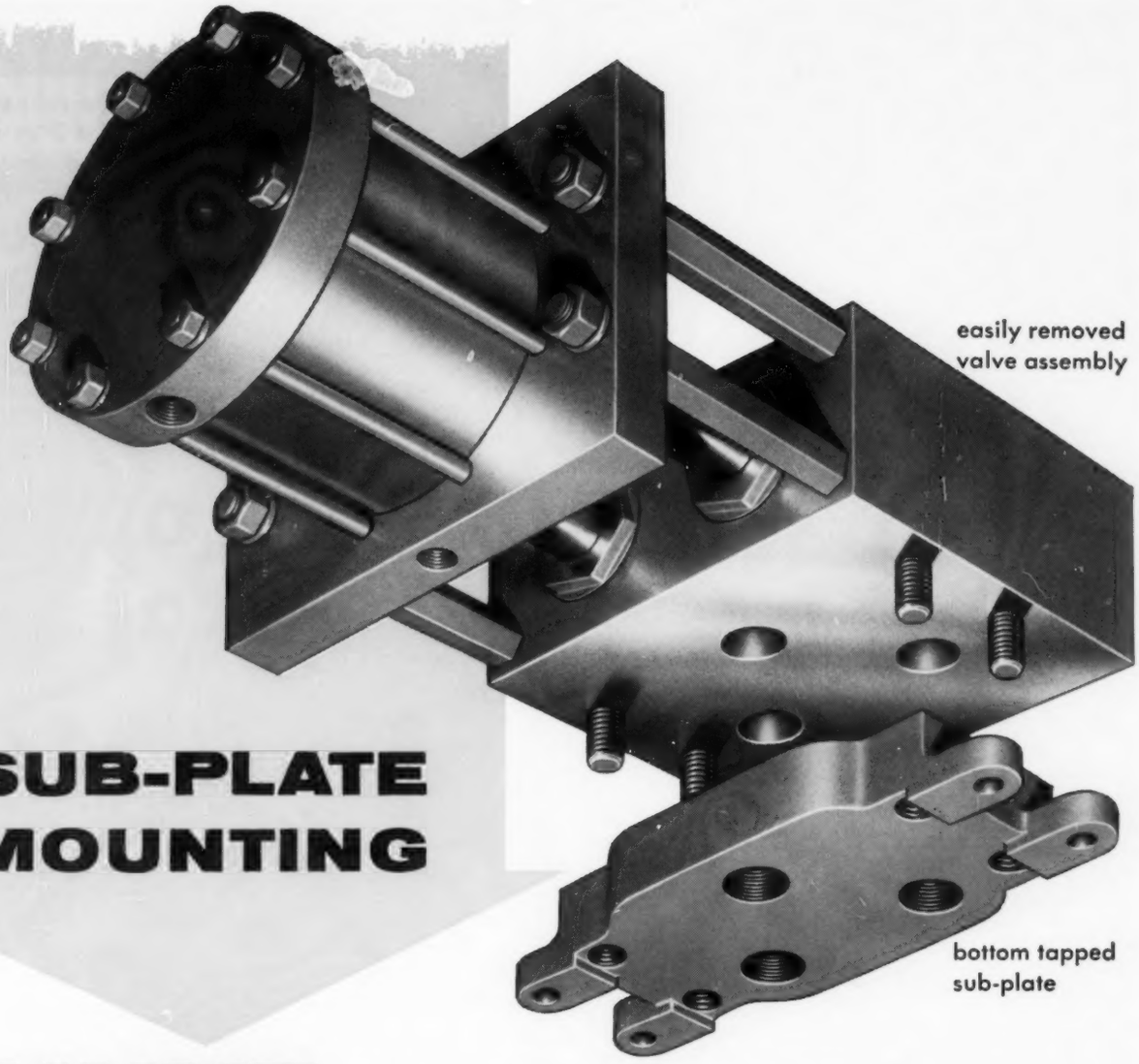
So how can we lick this toughy? One way is to build the reducer housing oversize, big enough to radiate the heat away and keep temperatures down. But this type sticks out in aisles, louses up compact designs and barks shins. Then, we might try a smaller housing complete with fins on it to dissipate the heat. If this still doesn't work, another trick is to use a reducer with capacities and ratings a step above the ones we need. This is sending a man to do a boy's job. It's impractical, inefficient and costly. There *has* to be an easier, better, saner and cheaper way to do it. And there is!

In certain cases, where the size and type of reducer permits and where we can gain enough in thermal HP rating to keep heat generation in bounds, Cone-Drive Gears does it with fan-cooling.

What's that? Simple. Just add a fan to the worm shaft plus the necessary air shields, fan cover, etc., and presto!—heat is no longer a problem. The air shields direct the fan-pushed air over the fins on the lower portion of the reducer. The fins are shaped and spotted to guide the air stream where it is needed. Thermal HP ratings are boosted tremendously, as high as 147% above those of standard reducers in some cases! Those over-worked, over-heated reducers will now do the job you bought them to do.

Other advantages? They're here in abundance. The size of the reducer stays the same. All parts on a Cone-Drive fan-cooled reducer are 100% interchangeable with parts for standard reducers. Oil capacity is identical. Shields are quickly removed without disconnecting the reducer. (This is important where severe operating conditions make periodic cleaning necessary). The reducer can also be operated *without* fan-cooling just by taking off the fan and shields.

This simple addition to standard Cone-Drive HU speed reducers might be just your answer—might save you some money. Write for Cone-Drive's Bulletin CD-218. It will tell you all about the full line of Cone-Drive double-enveloping worm gear reducers as well as the fan-cooled kind. Cone-Drive Gears, Div. Michigan Tool Co., 7171 E. McNichols Rd., Detroit 12, Mich.



SUB-PLATE MOUNTING

for HUNT Hydraulic Valves

- ***easier maintenance***
- ***minimum downtime***

Designed to fit into today's preventive maintenance programs, Hunt's new sub-plate mounting permits quick valve removal and installation.

With sub-plates, equipment downtime is cut to an absolute minimum . . . valves can be repacked in your maintenance shop instead of on the machine. And, once installed, permanent piping need never be disturbed.

O-ring seals between valve body and cast steel sub-plate assure leak-free sealing . . . bottom tapping of sub-plate affords maximum access to valves and eliminates piping clutter.

Sub-plate mounting is available on all ½ through 2 in. Hunt hydraulic valves.* To learn more about the performance and cost-cutting advantages of Hunt valves, contact your nearby Hunt representative.

*Except those with cast or forged bodies.

HUNT

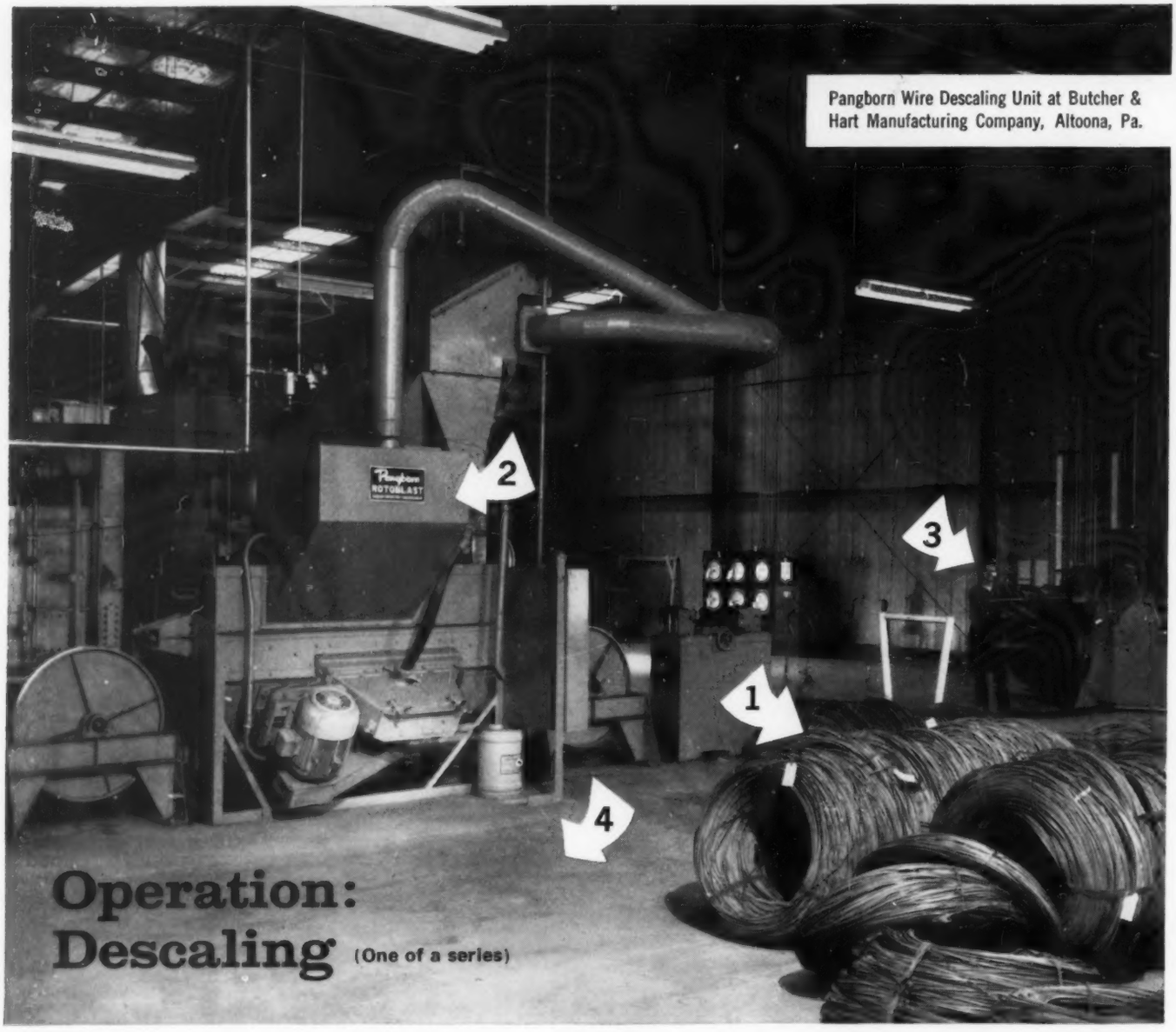
QUICK-AS-WINK® AIR AND HYDRAULIC

VALVES

HUNT VALVE COMPANY • DIVISION OF IBEC • SALEM, OHIO

Want more detailed information? Write Dept. ISE-161, Hunt Valve Company, Salem, Ohio. Ask for Bulletin 604.

3002



Q: Does Rotoblast end acid disposal problems?
A: Yes, and it cuts costs in the process.

1. Rotoblast eliminates loss of virgin metal

When wire and rod descaling is done through pickling, some virgin metal is invariably lost. Operating experience shows that there is no loss of virgin metal with Rotoblast Descaling. Also, there isn't any acid requiring disposal. Problems like water pollution are made obsolete in many areas of operation by Rotoblast.

2. Rotoblast reduces investments

With Rotoblast, savings on wire and rod descaling equipment can run as high as 70% on the original investment when compared with the investment required for pickling equipment.

3. Rotoblast minimizes descaling time

Wire and rod descaling goes faster with Pangborn Rotoblast than with pickling. Also, Rotoblast requires less manpower. Either way—or both—it cuts labor costs. (Following a patenting furnace, Rotoblast can descale multiple strands of wire, 40 or more at a time.)

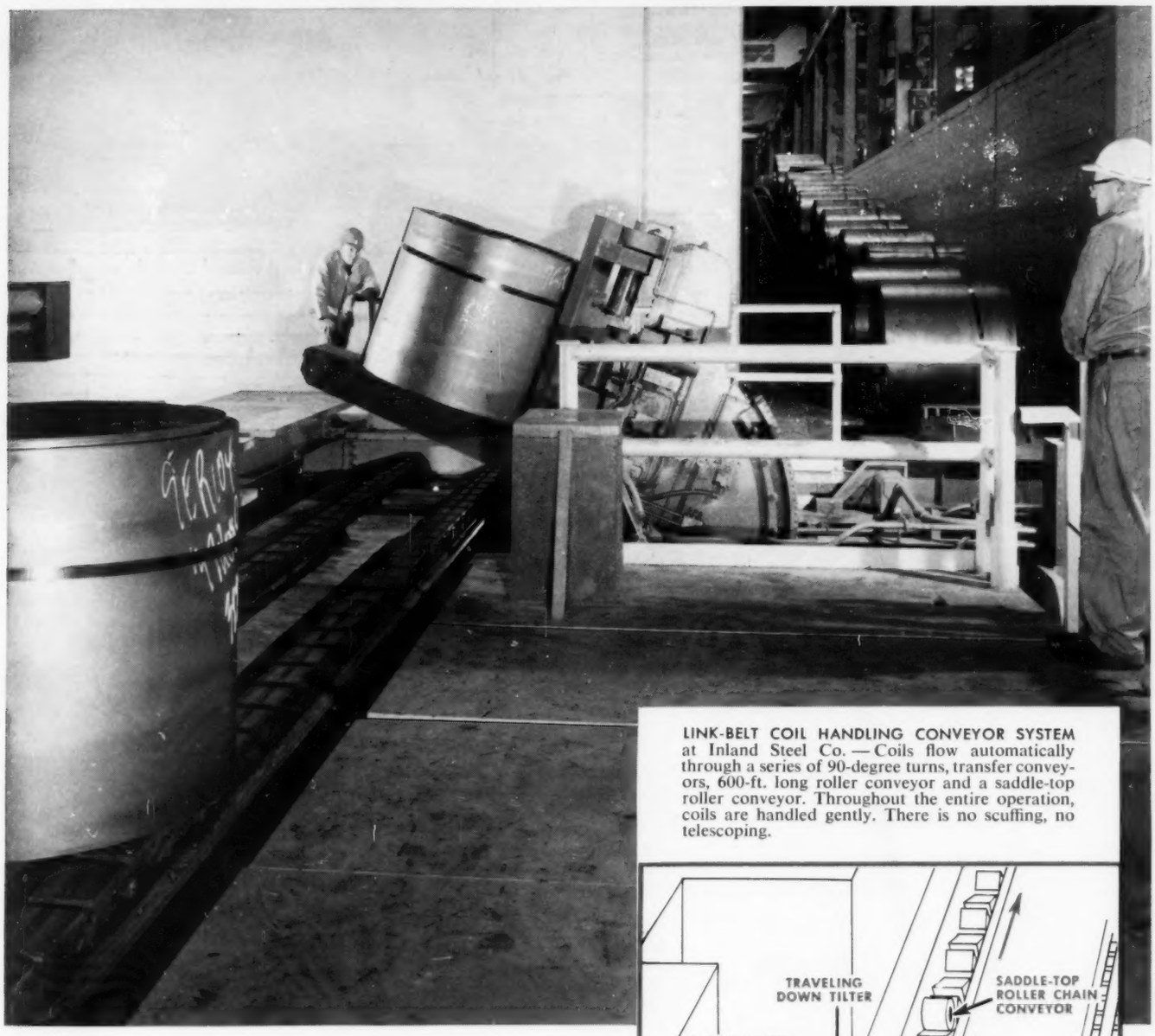
4. Rotoblast frees space

Since Rotoblast requires only ¼ to ⅓ as much space as pickling equipment, it frees the difference in floor space for other operations. Also, this airless-blast machine can be easily installed in line with coating and drawing equipment to provide straight-through production. Rotoblast-cleaned surfaces are ideal for any type of coating or for drawing compounds.

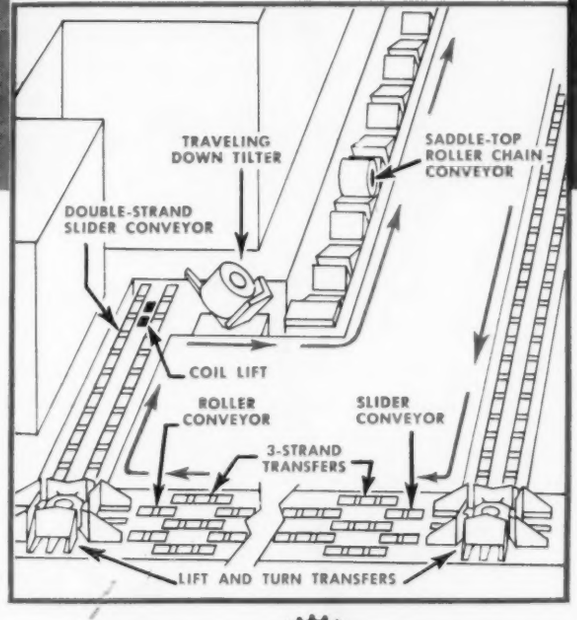
You, too, can effect considerable savings with the Rotoblast Descaling Unit in your wire and rod descaling operations. Talk with your Pangborn representative or write: PANGBORN CORPORATION, 4400 Pangborn Blvd., Hagerstown, Maryland. *Manufacturers of Blast Cleaning, Vibratory, Dust Control Equipment—Rotoblast® Steel Shot and Grit®.*

Pangborn
OF HAGERSTOWN

15-ton loads are "run-of-the-mill"



LINK-BELT COIL HANDLING CONVEYOR SYSTEM at Inland Steel Co. — Coils flow automatically through a series of 90-degree turns, transfer conveyors, 600-ft. long roller conveyor and a saddle-top roller conveyor. Throughout the entire operation, coils are handled gently. There is no scuffing, no telescoping.



LINK-BELT coil conveyors take on a tough handling job for Inland Steel

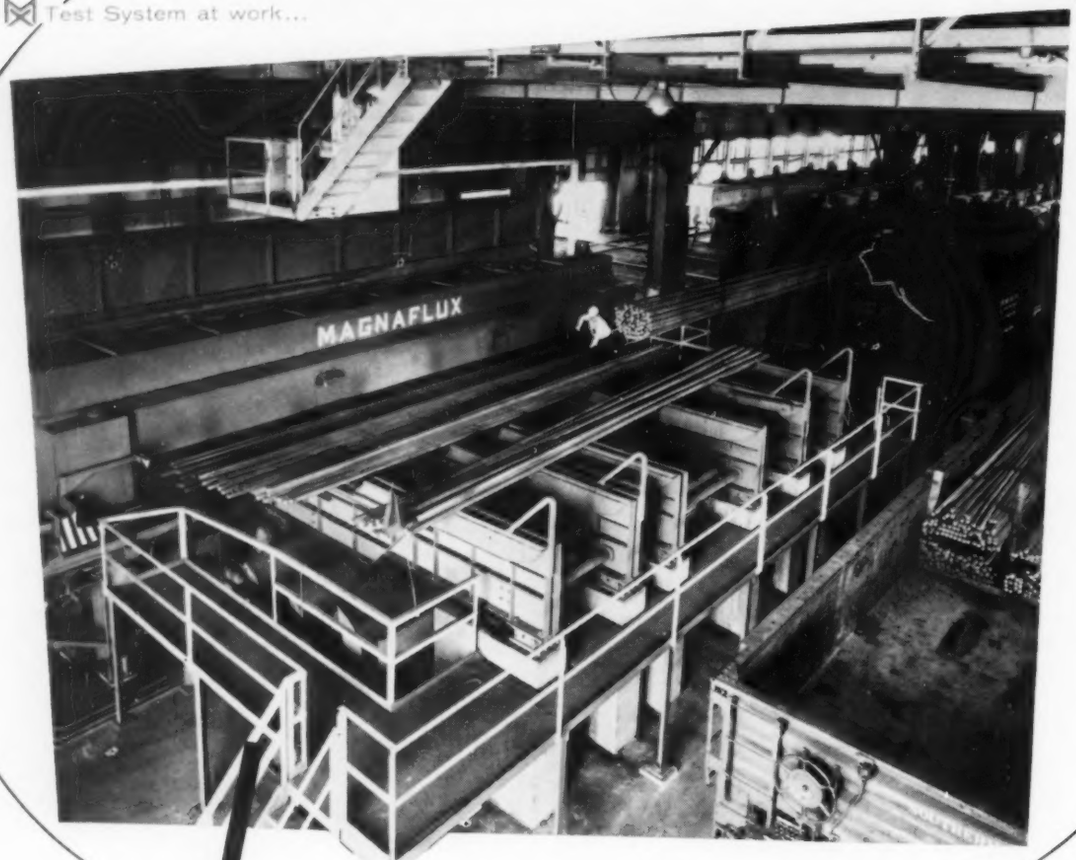
Putting these heavyweights through the mill without damage calls for sure, delicate handling. It's a difficult job performed with precision and safety on Link-Belt conveyors. Coils weighing 15 tons each move automatically from coiler to pickling line.

All through industry, Link-Belt is advancing materials handling to match the pace of production technology. In steel mills throughout the country, Link-Belt conveyors, processing and power transmission machinery—plus expert engineering—are helping to cut costs and improve plant output. For complete details on single units or complete systems, contact your nearest Link-Belt office. Ask for Book 2764. 15,390

LINK-BELT

One source . . . one responsibility for materials handling, processing and power transmission equipment

Another MX Test System at work...



Another Magnaglo Billet Conditioning Installation

This complete Magnaglo system was designed and produced by Magnaflux Corporation. It is just one example of Magnaflux ability to engineer and fabricate complete automated handling and testing systems for the steel industry.

A well-integrated Magnaglo inspection and handling system gives you better, more complete, control of billet quality from conditioning. And you can control the Magnaglo sensitivity to identify only the seams you want to scarf. This makes possible increased mill yield, substantially reduced billet conditioning costs, and consistently higher quality in the semi-finished state.

More and more mills are taking advantage of the years of experience gained by Magnaflux, the pioneer developer of magnetic particle test-handling systems for billets, tube rounds, and welded or seamless tubing and pipe. Now, how can we help *you*? Phone your local MX Field Engineer or write to Magnaflux Corporation, 7332 West Lawrence Ave., Chicago 31, Illinois.

MAGNAFLUX CORPORATION
A SUBSIDIARY OF GENERAL MILLS
General Mills
TEST SYSTEMS

MX Test Systems Include MAGNETIC PARTICLE, FLUORESCENT PENETRANT, THERMOGRAPHIC, EDDY CURRENT, ULTRASONIC, STRESS ANALYSIS, GAMMA RAY SERVICE, DYE PENETRANT & MAGNETIC FIELD

One of two Morgan 25/25 ton, 85' 0" span soaking pit cranes.

At J&L's Cleveland Works...

PRODUCTION GETS A LIFT FROM MORGAN CRANES

Morgan 75/15 ton, 85' 8" span heavy duty mill crane changing rolls on J & L's new 80" reversing roughing mill.

At the Cleveland Works, as well as at other J & L mills, Morgan cranes are earning their keep in vital production operations.

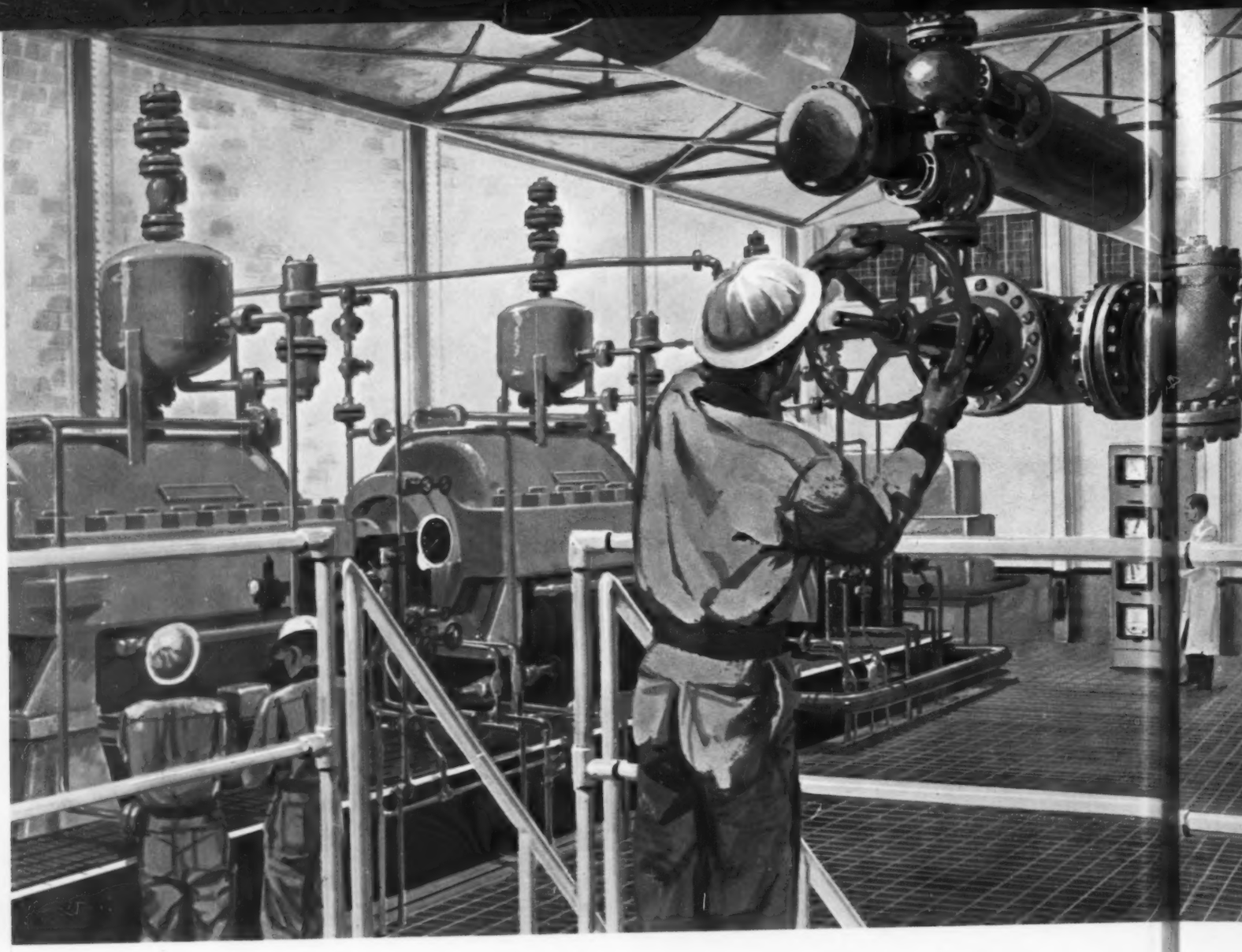
Here you see a mill-type crane, and a soaking pit crane, widely apart in capacity and function. They illustrate Morgan's awareness of a metals producer's exacting needs; and they both possess the rock-bottom operating and maintenance cost factors for which Morgan cranes are famous.

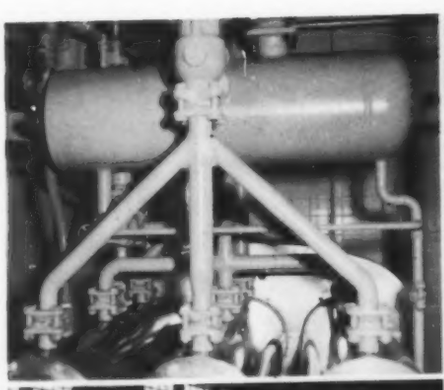
When you decide to expand or modernize, get the crane facts from Morgan—then put an experienced Morgan Representative on your planning team.

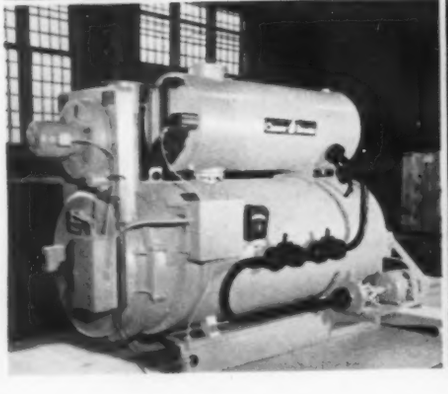
THE
MORGAN
ENGINEERING CO. *Alliance, Ohio*

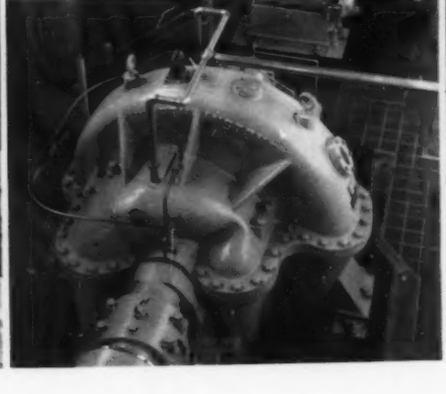
ELECTRIC OVERHEAD CRANE INSTITUTE E.O.C.I. MEMBER

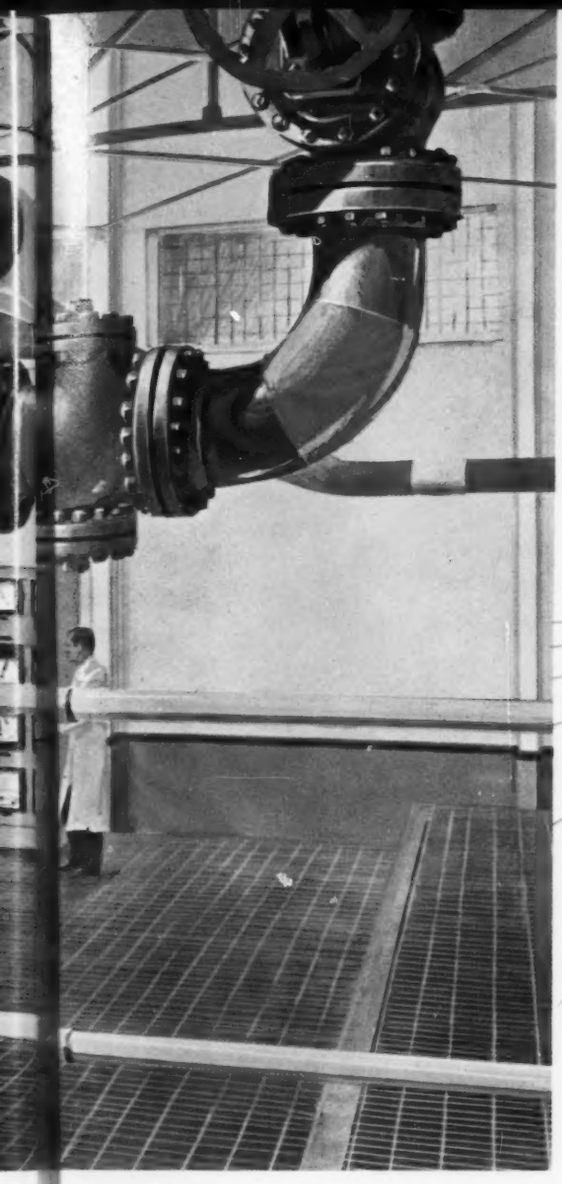
Overhead electric traveling cranes, gantry cranes,
open hearth special cranes, blooming mills, structural mills,
shears, saws, auxiliary equipment and welded fabrications











Rust-Oleum

NEW COLOR HORIZONS

System

HERE is a modern, functional *system* that combines four important points. (1) the ability to stop rust, (2) modern color harmony, (3) durability to last and last, (4) ease of application. From machinery, equipment, and structural steel to tanks, steel fences and metal sash – the Rust-Oleum New Color Horizons System can provide lasting beauty in the colors of your choice. Ask your Rust-Oleum Industrial Distributor, together with your Rust-Oleum Factory Specialist, to make a survey of your plant and provide complete recommendations. Rust-Oleum Industrial Distributors maintain complete stocks for prompt delivery in all principal cities of the United States, Canada, and in many countries around the world.

Rust-Oleum, in its various forms, can also save you time and money on problems like these: Heat Resistance, Water Resistance, Chemical Resistance, Coating Galvanized Metal, Speedy-Dry Coatings (less than thirty minutes to dry).

PROVED THROUGHOUT INDUSTRY FOR OVER THIRTY-FIVE YEARS

RUST-OLEUM®

See our catalog in Sweet's.

STOP RUST by applying Rust-Oleum 769 Damp-Proof Red Primer directly over the sound rusted surface

Save time, money, and metal. Brush Rust-Oleum 769 Damp-Proof Red Primer right over the remaining sound rusted surface after scraping and wirebrushing to remove rust scale and loose rust. **Specially-processed** fish oil vehicle penetrates rust to bare metal as proved in radioactive tracing studies.

STOPS RUST!®

Distinctive as your own fingerprint. There are imitations, but only one Rust-Oleum.

Insist upon industry-proved Rust-Oleum. Accept no substitute.

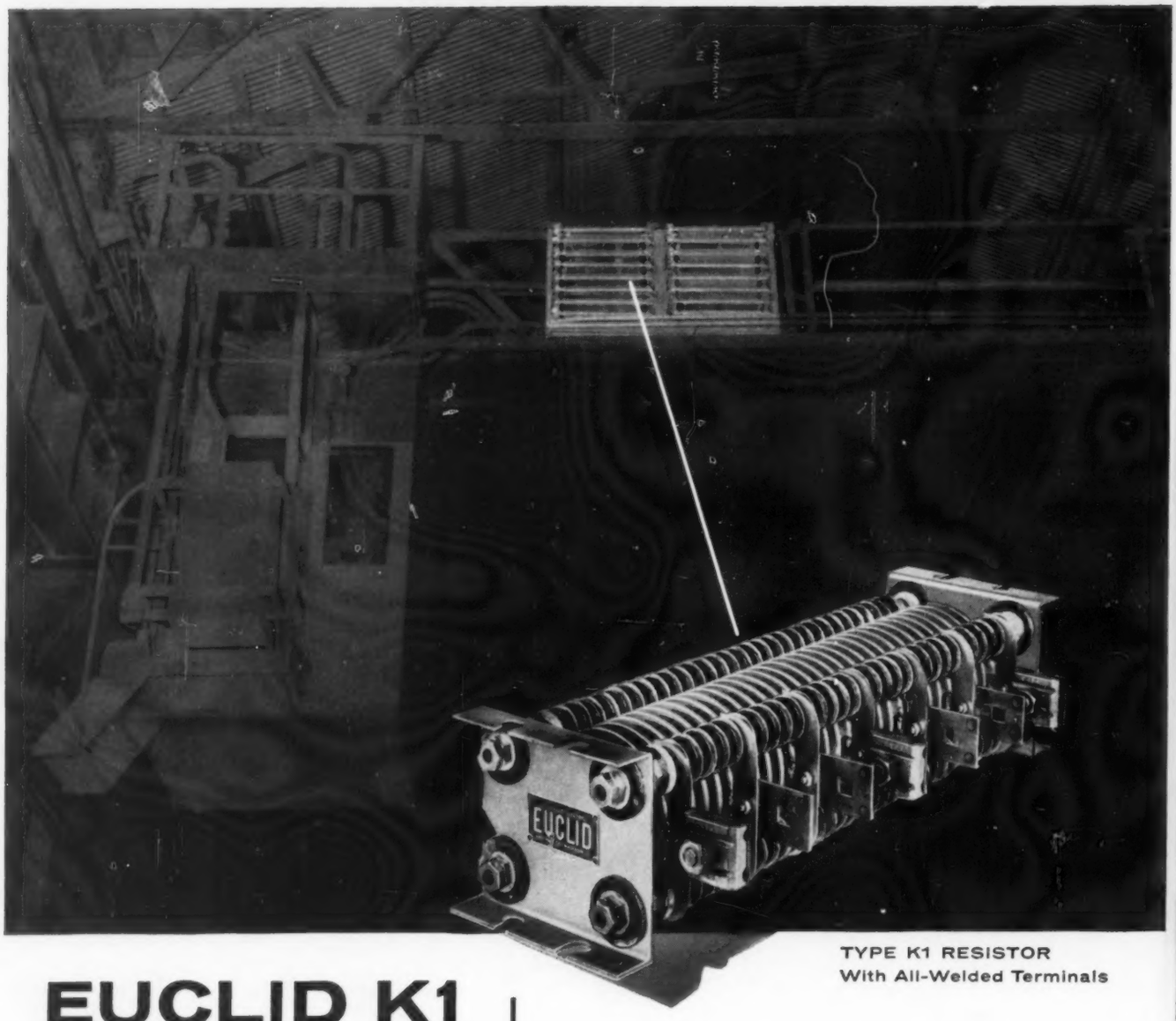
You take the brush! Try a free test sample!

ATTACH TO YOUR LETTERHEAD

RUST-OLEUM CORPORATION
2985 Oakton Street • Evanston, Illinois

At no cost or obligation, please send me:

- ☐ New full-color catalog on New Color Horizons System and specialized Rust-Oleum systems, including color charts and applications.
- ☐ FREE TEST SAMPLE of Rust-Oleum 769 Damp-Proof Red Primer.
- ☐ Please have your representative contact us to discuss a plant survey.



TYPE K1 RESISTOR
With All-Welded Terminals

EUCLID K1 Heavy-duty Resistors

Installation on Steel Mill Crane

Specify **EUCLID** Type **K1** King-Size Resistors
the next time you have a resistor burnout!
(38 to 200 amperes capacity based on 375°C rise)

Please contact your nearest EUCLID Representative

WHAT'S YOUR PROBLEM?
Ask for Bulletin 3004

The EUCLID Electric & Mfg. Co.
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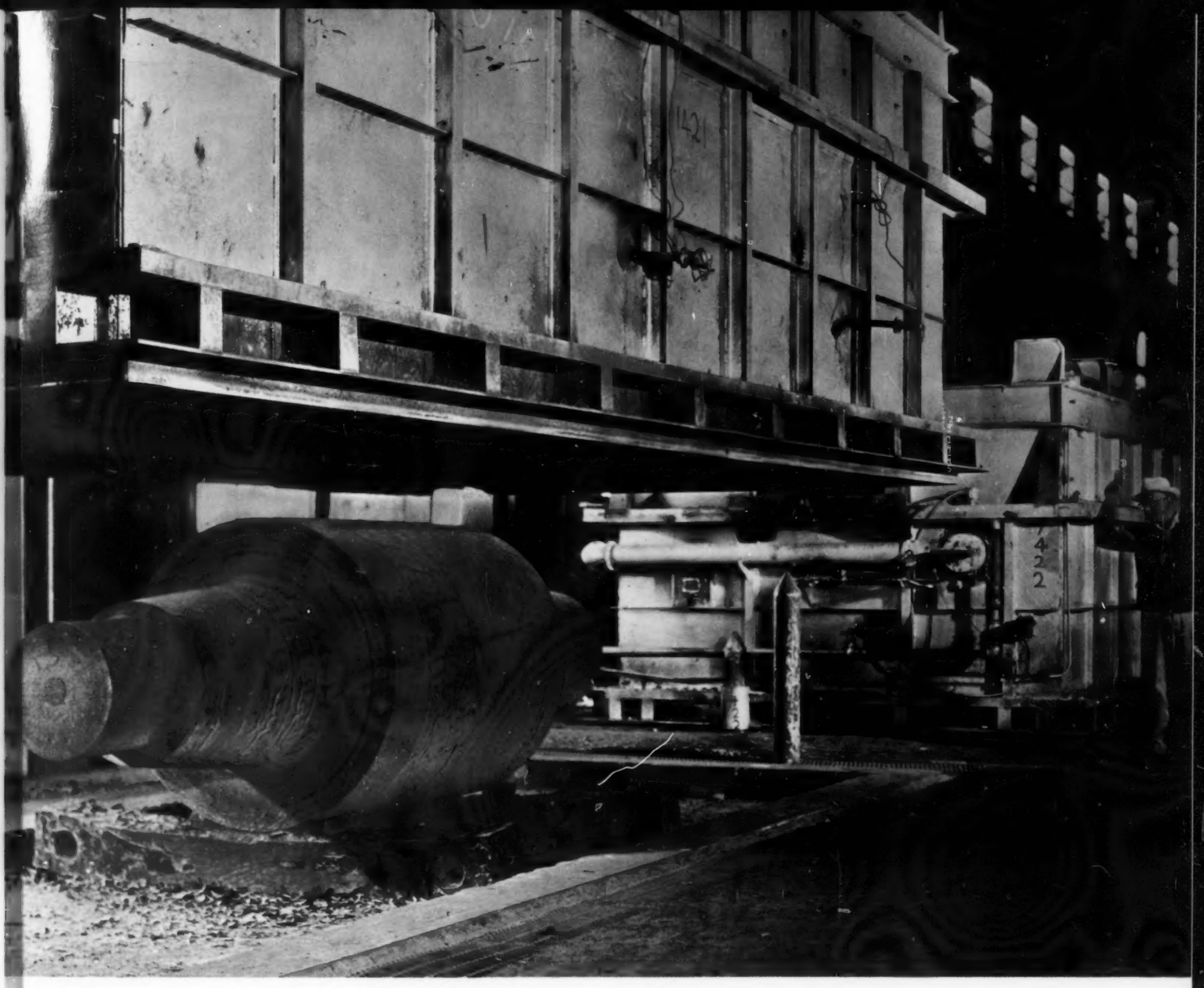


We do it better without the Nubians...

According to legend, the master armorers of Damascus tempered their world-famous swords by thrusting them red hot into living Nubian slaves. It was rough on the slaves, but it produced blades of unmatched strength and keenness. Foundrymen at our Midland plant achieve similar effects in cast steel mill rolls with big annealing furnaces like these. We heat the newly-cast rolls to red or yellow heat for a carefully controlled time period, and then cool them, again under precisely controlled conditions, by water or air. We can produce any property or combination of properties the mill operator needs in his rolls. It's more difficult than the old Damascus heat-and-quench cycle, but it's more effective. This care in heat treating and annealing...and at every other step in production...is the reason why *you get more tonnage from the rolls with the Striped Red Wabblers.*

MACKINTOSH-HEMPHILL • PITTSBURGH • U.S.A. DIVISION

BLISS

MACKINTOSH-HEMPHILL • Division of E. W. BLISS COMPANY

Pittsburgh and Midland, Pa.

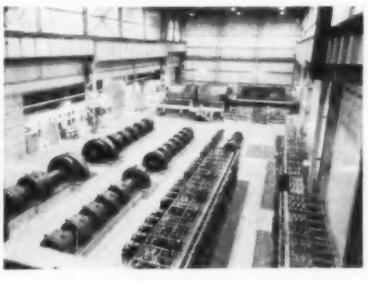
ULTRA-PURE AIR creates healthy motors

cleaned by Wheelabrator® air filters

Dust-free atmosphere is essential to dependable and continuous motor operation, and Ultra-Filtration can provide the degree of air purity you require, at minimum cost. Savings in motor and blower maintenance costs alone can return more than the cost of Ultra-Filtration equipment in a short time.

In prominent American and Canadian steel plants, Wheelabrator Ultra-Filtration installations are providing over 5,000,000 cfm of super-clean air for motor rooms, electrical equipment, control rooms and turbo blowers. Collection efficiencies above 99% by weight and 95% by blackness test are regularly maintained, even when filtering sub-micron size particles.

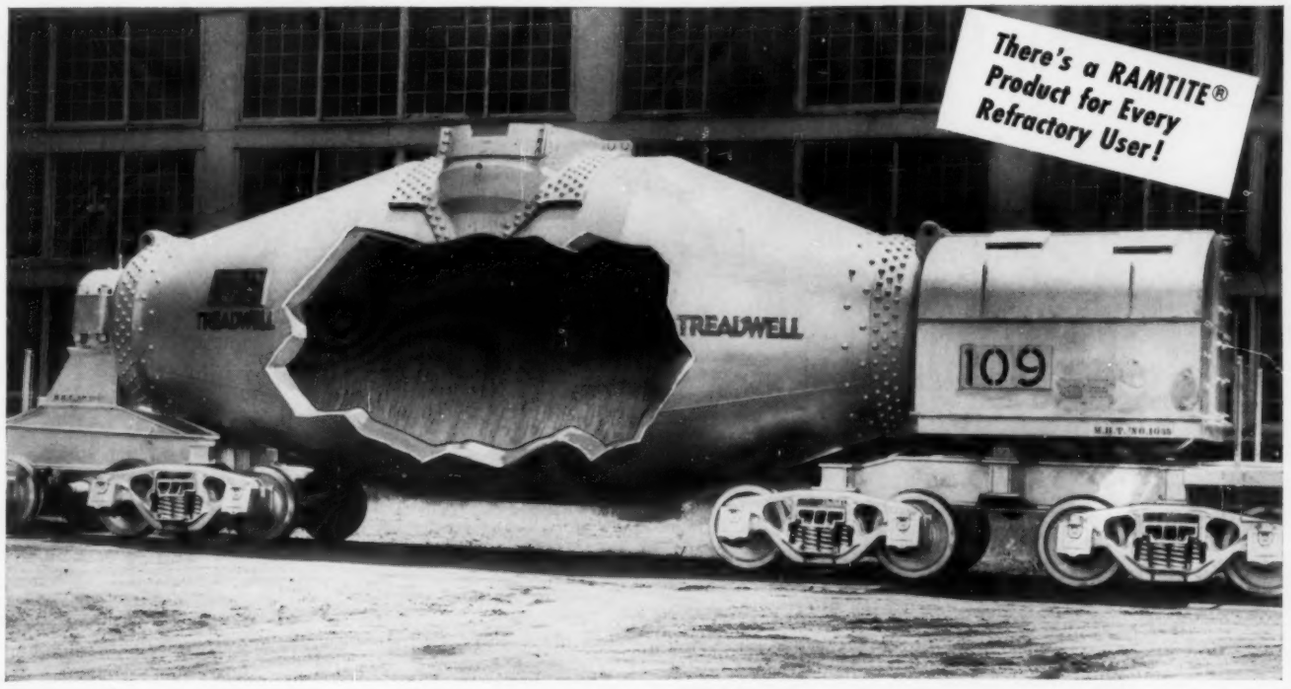
In cost of operation, Wheelabrator Ultra-Filtration equipment has proven to be the most economical method that provides the necessary level of filtering efficiency. No liquids, oils or tacky materials are involved in its operation. There is no problem of sludge removal. In fact, not one cent for maintenance has been spent in filtering 364,000,000,000 cubic feet of air in a typical application.



For detailed information on Ultra-Filtration equipment in steel mill applications, see your Wheelabrator Dust and Fume Engineer or write to Wheelabrator Corp., 396 S. Byrkit St., Mishawaka, Ind. In Canada, Wheelabrator Corp., P. O. Box 490, Scarborough, Ontario.

WRITE TODAY for your copy of Catalog 562-D, illustrating uses of Wheelabrator Dustube and Ultra-Filtration equipment in steel mills and other industries.

WHEELABRATOR
DUST AND FUME CONTROL



Poured 82,360 Tons plus 40,640 Tons!!

—and still going strong!

Additional proof of the value and added versatility of 90-RAM® DPM is evidenced in an Eastern steel mill. A 200-ton Treadwell ladle was resurfaced with 90-RAM DPM on June 18, 1960, after carrying 82,360 tons. As of November 14, 1960, the ladle had carried an additional 40,640 tons and as of December 2, 1960, was still in service.

This particular gunning application is being used in four other large steel mills with gratifying results.

90-RAM is a 90% Alumina Ramming Mix, available in DPM (Dry Pre-mixed form) and plastic ready-to-use form. This RAMTITE product has resistance to extremely high temperatures, abrasion, spalling and deformation.

68 HOURS
vs. 12-14 DAYS

Cooling — 24 hours
Gunning — 8 hours
Heating — 36 hours

Back on line in 68 HOURS instead of the usual 12-14 DAYS

Saves DAYS of Outage Time

90-RAM DPM Pays Large Tonnage Dividends on Torpedo Ladles!

Among the many applications of 90-RAM DPM is its use to line blast furnace ladles and the torpedo ladles. Note the chart showing saving of outage time.

Ask for a RAMTITE sales representative to call to discuss your refractory problems or write for information about your particular needs. Use the coupon.

The Ramtite Co.
DIV. OF THE S. OBERMAYER CO.
1813 S. Rockwell St., Chicago 8, Illinois

THE RAMTITE CO., Div. of The S. Obermayer Co.
1813 S. Rockwell St., Chicago 8, Illinois

Please send the items checked:

☐ Information on Lining Ladles
☐ Folder on 90-RAM
☐ Representative (without obligation)

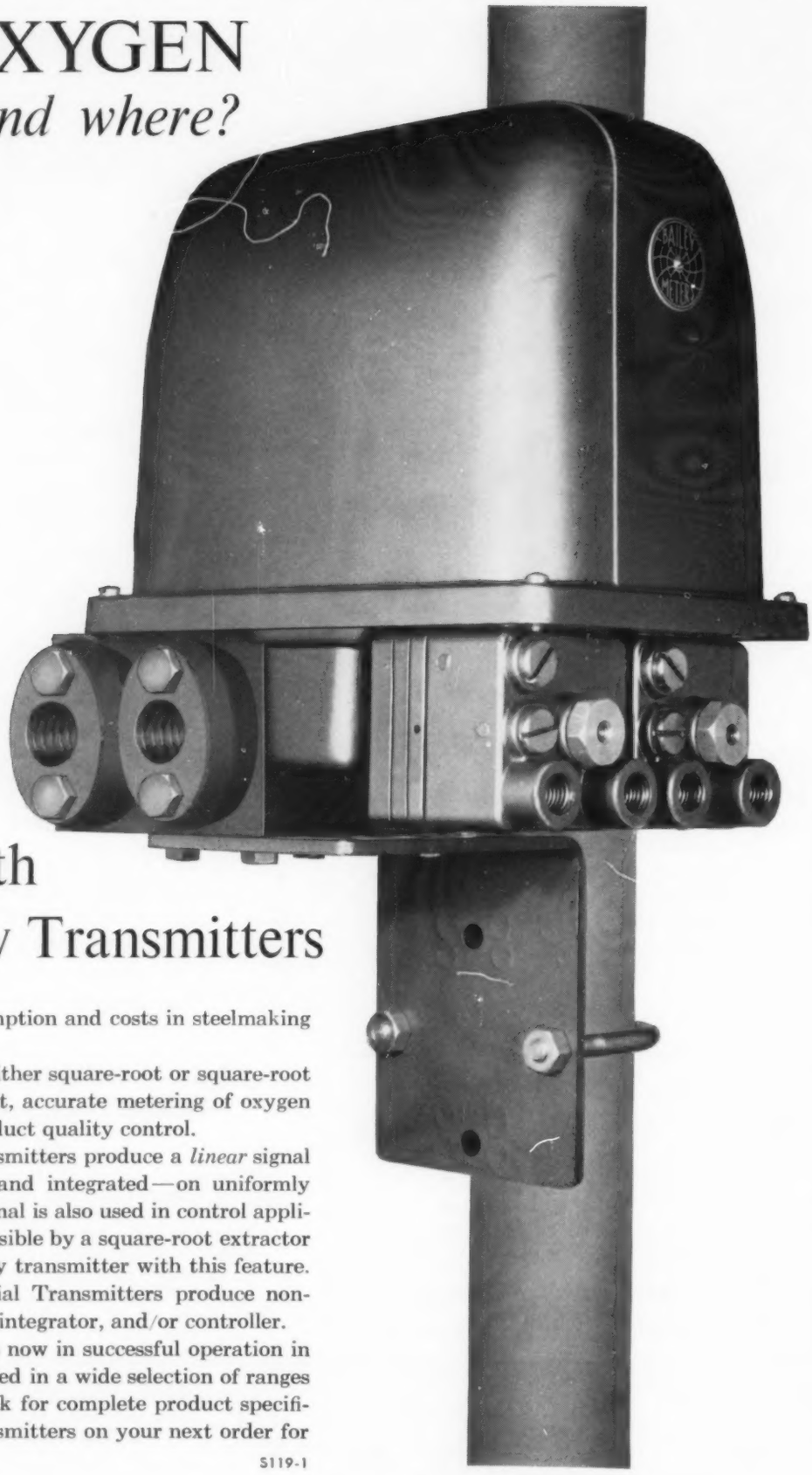
Company Name_____

Attn. Mr._____ Title_____

Address_____

City_____ Zone____ State_____

How much OXYGEN do you use..*and where?*



KNOW.. accurately..with Bailey O_2 Flow Transmitters

Why wonder about oxygen consumption and costs in steelmaking applications?

Bailey O_2 Flow Transmitters—either square-root or square-root extracting types—provide constant, accurate metering of oxygen use for better cost records and product quality control.

Bailey Force Balance Flow Transmitters produce a *linear* signal of flow which can be recorded—and integrated—on uniformly graduated scales or charts. This signal is also used in control applications. Linear signals are made possible by a square-root extractor integral with transmitter—the only transmitter with this feature.

Bailey Force Balance Differential Transmitters produce non-linear signals of flow to a recorder, integrator, and/or controller.

Bailey O_2 Flow Transmitters are now in successful operation in leading steel mills. They are supplied in a wide selection of ranges which may be readily adjusted. Ask for complete product specifications—specify Bailey Flow Transmitters on your next order for distribution meters.

S119-1

IRON AND STEEL DIVISION

BAILEY METER COMPANY

1047 IVANHOE ROAD • CLEVELAND 10, OHIO

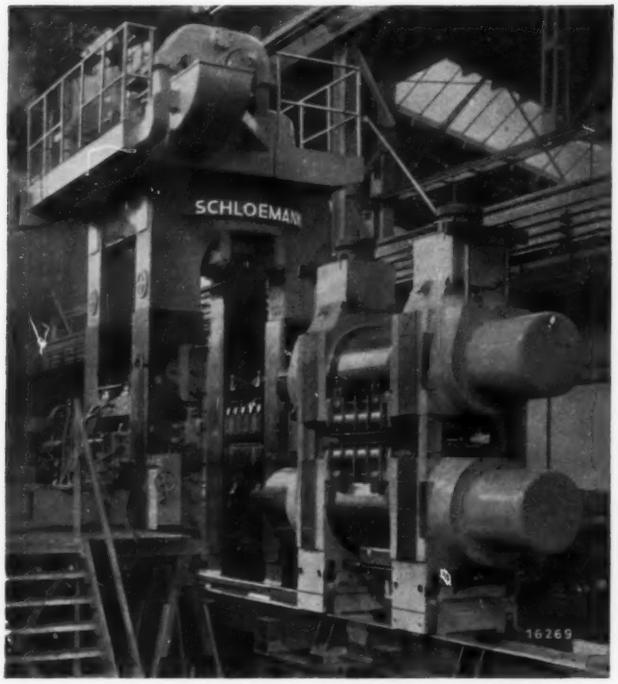
In Canada—Bailey Meter Company Limited, Montreal

UDC 621.944.9

SCHLOEMANN
ROLLING MILLS · HAMMERS · PRESSES

Multi-purpose rolling mill for "refractory" materials

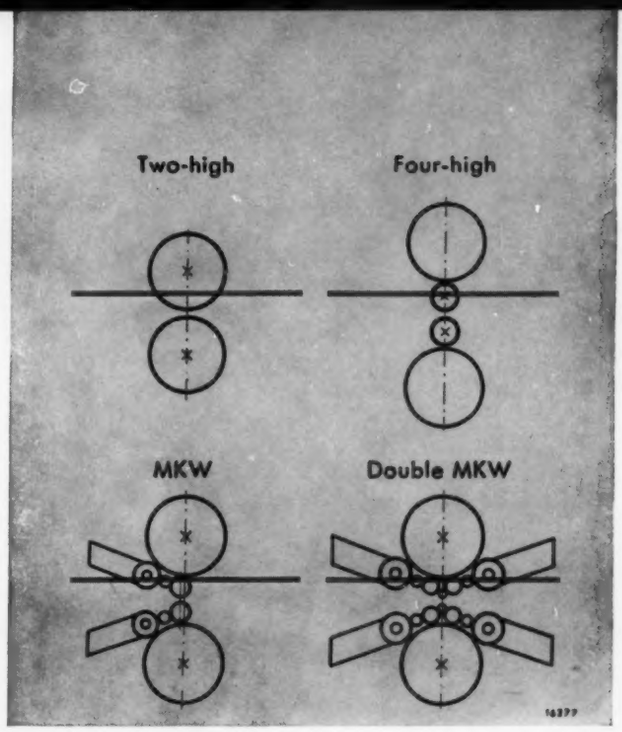
Special alloys for the nuclear power and other industries have presented extraordinary problems. The new MKW mill (US and foreign patents) developed by SCHLOEMANN is ideally suited for rolling these refractory materials and is readily adaptable



MKW 80 during workshop assembly. Above, the double MKW set-up is seen in run-out position; below, the view from the entry side shows the pay-off reel and coiler.

for conventional rolling work. Typical characteristics as included in the specifications of an MKW mill recently built for operation in the United States are as follows:

Hot and cold rolling – Initial thickness up to 2" Final thickness of strip – .006" standard; .001" min. Rolling force – in excess of 2200 tons at 24" strip width (twice the roll separating force required for rolling of conventional CrNi steels).



Four different roll set-ups for one mill:

Two-high set-up: 36" ∅ rolls

Four-high set-up: 16½" ∅ driven work rolls

MKW set-up: 36" ∅ driven back-up rolls, 5" to 5½" ∅ work rolls

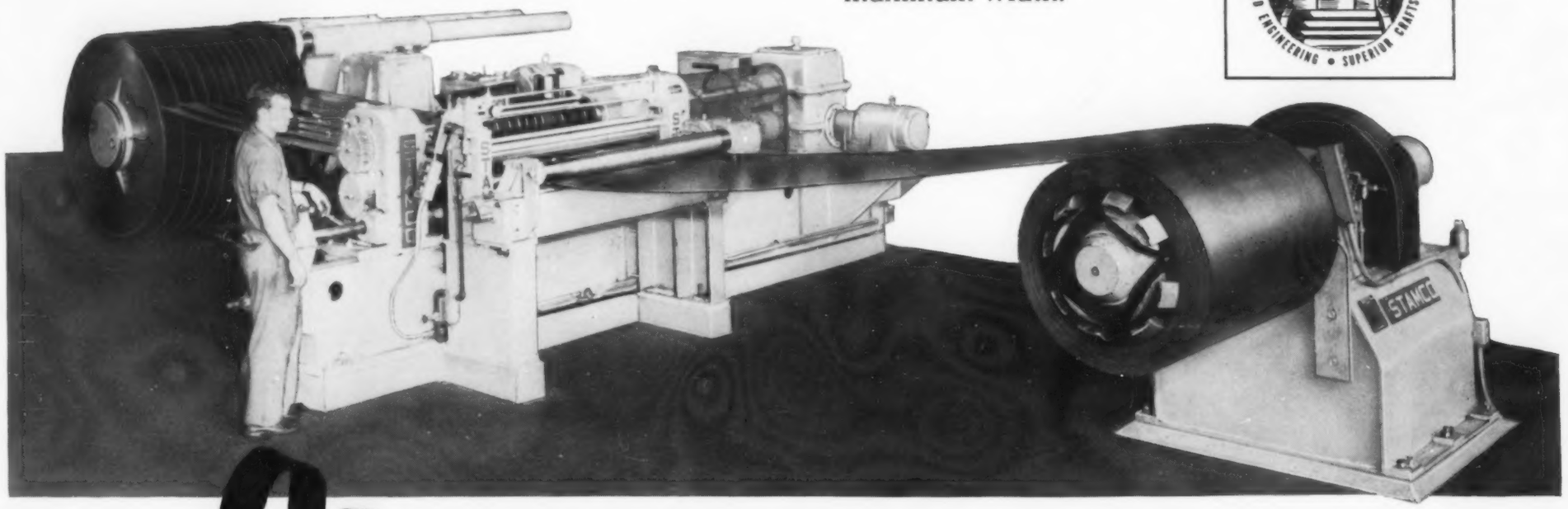
Double MKW set-up: 36" ∅ driven back-up rolls, 2" to 2¼" ∅ work rolls

Wide working range

The mill is equipped with four different roll set-ups and is thus provided with an extremely wide working range. Since the new super high-grade but difficult-to-work materials are currently required in comparatively small quantities only, the use of one MKW mill with four different roll set-ups offers practical and economical advantages.

FELLER ENGINEERING COMPANY 1161 Empire Building, Pittsburgh 22, Pa.

Stamco *slitting and coiling line for coils of 20 thousand lbs. maximum weight, 52 inches maximum width.*



Stamco, a leader in slitting, coiling and shearing equipment, is in a position to furnish equipment to meet any requirement. Trained sales personnel will gladly consult with you. Write for details to: Stamco, Inc., New Bremen, Ohio, U. S. A.

slitting and coiling lines • cut-to-length lines • flying shear lines • power squaring shears • continuous process lines • ferrous or non-ferrous mill equipment

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Quiet

that noisy *EXHAUST*

AIR-GAS-STEAM

PULSCO BLOWDOWN MUTE*

Eliminate ear splitting fatiguing plant noise from exhaust vents with patented PULSCO Blowdown Mutes. Capacity: From 1,500 to 500,000 cfm air and gas. 3,000 to 1,000,000 lb/hr steam. Temperatures to 1,200° F. Overall sound pressure level reduced to 80 - 86 decibels at 100 ft. Excellent silencing plus separating and collecting condensate. Drain provided.

PULSCO MULTIPLE TUBE BLOWDOWN MUTE WITH REPLACEABLE TUBE BUNDLE

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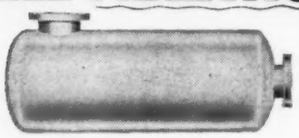
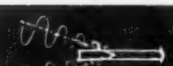
KILL VIBRATION with PULSCO



Representatives in all principal cities

LIQUID PULSE TRAPS
Subdues Pipeline Vibration

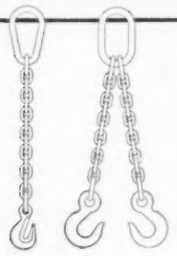
Eliminates meter error.
Extends valve life.
For all types of rotary, reciprocating and plunger pumps.



PULSATION CONTROLS CORPORATION
JAckson 5-6641 P.O. Box 169 • SANTA PAULA, CALIF.

HERC-ALLOY

The Original Alloy Chain



● Has many superior features—is lighter, therefore easier to handle...is long wearing...has high resistance to impact loading...is Inswell welded. Chain and all fittings are 125,000 p.s.i. tensile strength alloy steel.

● Write for Bulletin 100 covering Herc-Alloy Sling Chains, including helpful information on their care, use and inspection.

● Sold in running lengths, slings assembled to customers' specifications and other special assemblies.

RUGGED · DURABLE CM® CHAIN

COLUMBUS McKINNON CHAIN DIVISION
COLUMBUS McKINNON CORPORATION
TONAWANDA, NEW YORK
NEW YORK • CHICAGO • CLEVELAND
SAN FRANCISCO
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HERC-ALLOY®

SPRAYING SYSTEMS CO.

DESCALING NOZZLES

in hardened stainless steel

in stainless steel with tungsten carbide orifice tips

* **compact**
modern design . . . only ½ to ⅓ the size of old nozzle types

* **advanced hydraulic design**
gives extremely sharp, hard hitting FLAT SPRAY pattern

* **large open orifice**
keeps clogging to a minimum

Here are spray nozzles with sharp, high-impact flat spray patterns to materially improve your descaling operations. They're small in size for easier installation and better performance. The unusually large orifices go far in solving clogging problems. Made in all capacities in hardened stainless steel for high resistance to sand and silt. And for maximum possible abrasion resistance, they're also made with Tungsten Carbide orifice inserts. Just write . . . we'll be happy to send you complete Descaling Spray Nozzle information.

HEAVY DUTY LINE STRAINERS

Spraying Systems now offers line strainers in a full range of sizes . . . with threaded connections up to 4" N.P.T. size . . . and flanged connections in 3", 4" and 6" pipe size. Designed for operation at pressures up to 125 psi. Unusually large screen areas for high volume capacity. Heavy duty, reinforced screens. Easily flush-cleaned through bottom plug or drain cock. Write for Bulletin 94.

SPRAYING SYSTEMS CO.

3262 RANDOLPH STREET • BELLWOOD, ILLINOIS

HOW WESTERN GEAR SERVES THE STEEL INDUSTRY

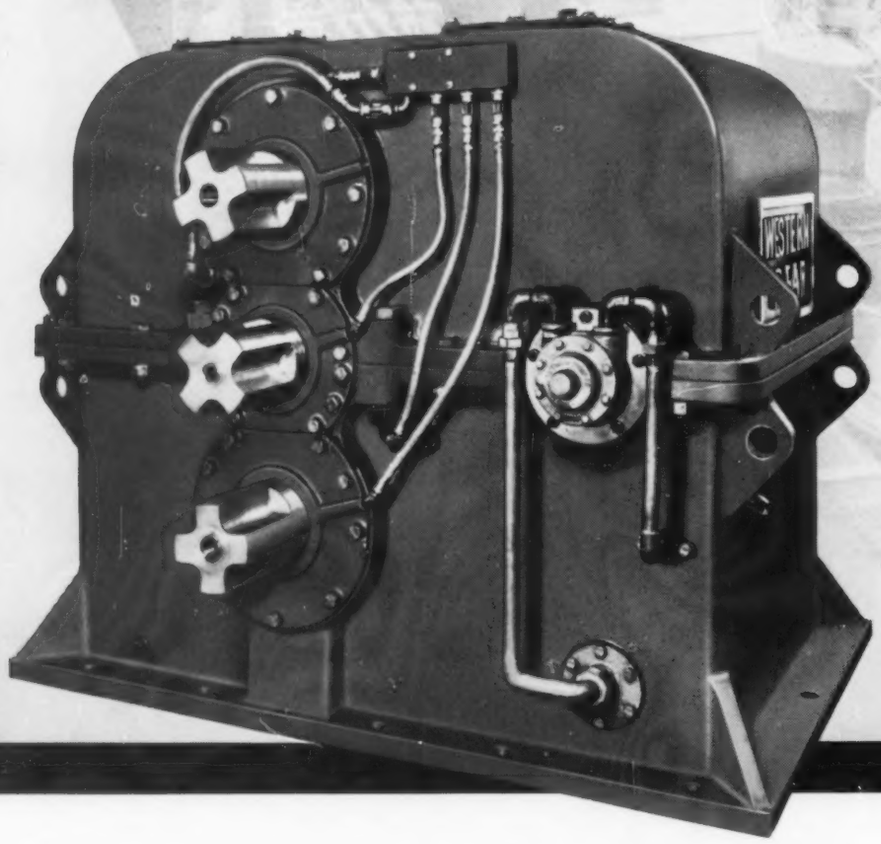
WESTERN GEAR

STEEL MILL EQUIPMENT SAVES YOU MONEY

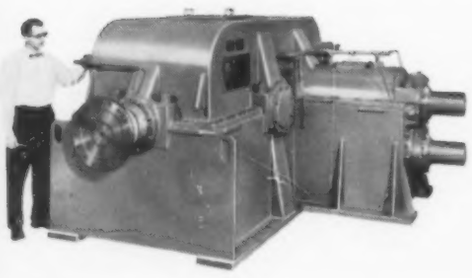
because...on the long run... **QUALITY COSTS YOU LESS!**

From the early days of the steel industry, Western Gear has made continuing studies of the industry's requirements. Today, many major steel mills are equipped with Western Gear speed reducers, pinion stands and combination reducers-pinion stands. ■ Why? Because Western Gear has earned an industry-wide reputation for reliability, and for being able to engineer and deliver the latest in metallurgical developments, tooth design, bearings, and overall rugged construction. ■ Take advantage of this intimate knowledge of America's steel industry. Ask for a Western Gear steel mill application engineer to talk to you about Western Gear's answers to your steel mill needs. For full information ,write, wire or phone collect to: **WESTERN GEAR CORPORATION** Industrial Products Division, P.O. Box 126, Belmont, California • LYtel 3-7611

WG INDUSTRIAL PRODUCTS DIVISION

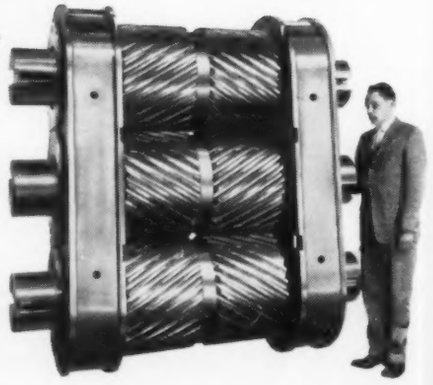


This 3-high pinion stand is combined in one housing with the reduction gears... gives you heavy savings in installation costs and valuable mill floor space. Alloy steel shafts are equipped with anti-friction bearings. Heat treated gears are lubricated by self-contained, circulating oil system. Double helical pinions precision shaved for maximum tooth contact and smoothness of operation. Housing is of heavy, welded, stress-relieved construction.



◀ This 10½ ton integral pinion stand and reducer averages 65% total length as compared to separate units... saves valuable space. First cost lower because fewer parts are involved. Installation costs lower, too, because installation is simpler, faster. Easy to maintain... fewer parts to wear ... large inspection opening simplifies repairs.

Shown here is a 22" center distance 3-high pinion stand ready for placement in the drive housing. Note shaft ends are keyed to allow use of cast wobbler extensions which can easily be replaced when worn out. This is a Western Gear development, designed to meet a specific steel mill customer's requirements. ▶



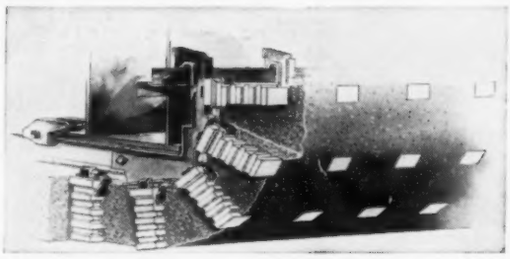
Why You CAN DEPEND ON DETRICK For

MAXIMUM PERFORMANCE

With

MINIMUM MAINTENANCE

In MONOLITHIC REFRACTORY CONSTRUCTIONS



Detrick engineering assures design, materials and application methods best suited to the economic and operational requirements of the job. Illustration shows detail of monolithic nose construction.

What do you look for in your search for top-efficiency refractory constructions?

Experience? **Detrick has been engineering refractory constructions, and pioneering improved refractory designs, since 1913—a 47-year record of successful installations.**

Engineering? **Detrick Engineering Department, largest in the field, is staffed by specialists familiar with every type of refractory problem and condition.**

Service? **Detrick's reputation is built on service — immediate, interested service by competent men operating from a worldwide network of offices and representatives.**

Whether the need is for monolithic or any other type of refractory construction, you can depend on Detrick for maximum performance with minimum maintenance. Write for "Engineered Monolithic Refractory Constructions" — Bulletin D-39.

Monolithic Department

M. H. DETRICK COMPANY

111 WEST WASHINGTON STREET • CHICAGO 2, ILLINOIS

Pittsburgh Office: 1607 Oliver Building

Offices and Representatives in All Principal Cities

DETRICK Steel ENCLOSURES ®

DETRICK REFRACTORY CONSTRUCTIONS

ENGINEERED TO THE JOB

• This Merchant Bar Mill, recently delivered to Ceco Steel Products Corporation at Lemont, Illinois, has many automatic features including escapement repeaters and mechanical turning devices enabling it to handle all bars mechanically.

The *14*-stand mill, designed to roll mild steel, includes a 4-stand in line roughing mill, a 4-stand intermediate continuous mill, a cross country mill and a continuous finishing mill. It rolls rounds, squares, deformed reinforcing bars, flats, angles and architectural window sash sections.

Designed by Birdsboro, in cooperation with Ceco Engineers, this mill is another example of our ability to give customized mill equipment assistance to steel producers. Your Birdsboro representative can tell you about other cases which may closely parallel your own. Call him in soon. *Sales Department, Engineering Department and Mfg. Plant:* Birdsboro, Pa.; *District Office:* Pittsburgh, Pa.

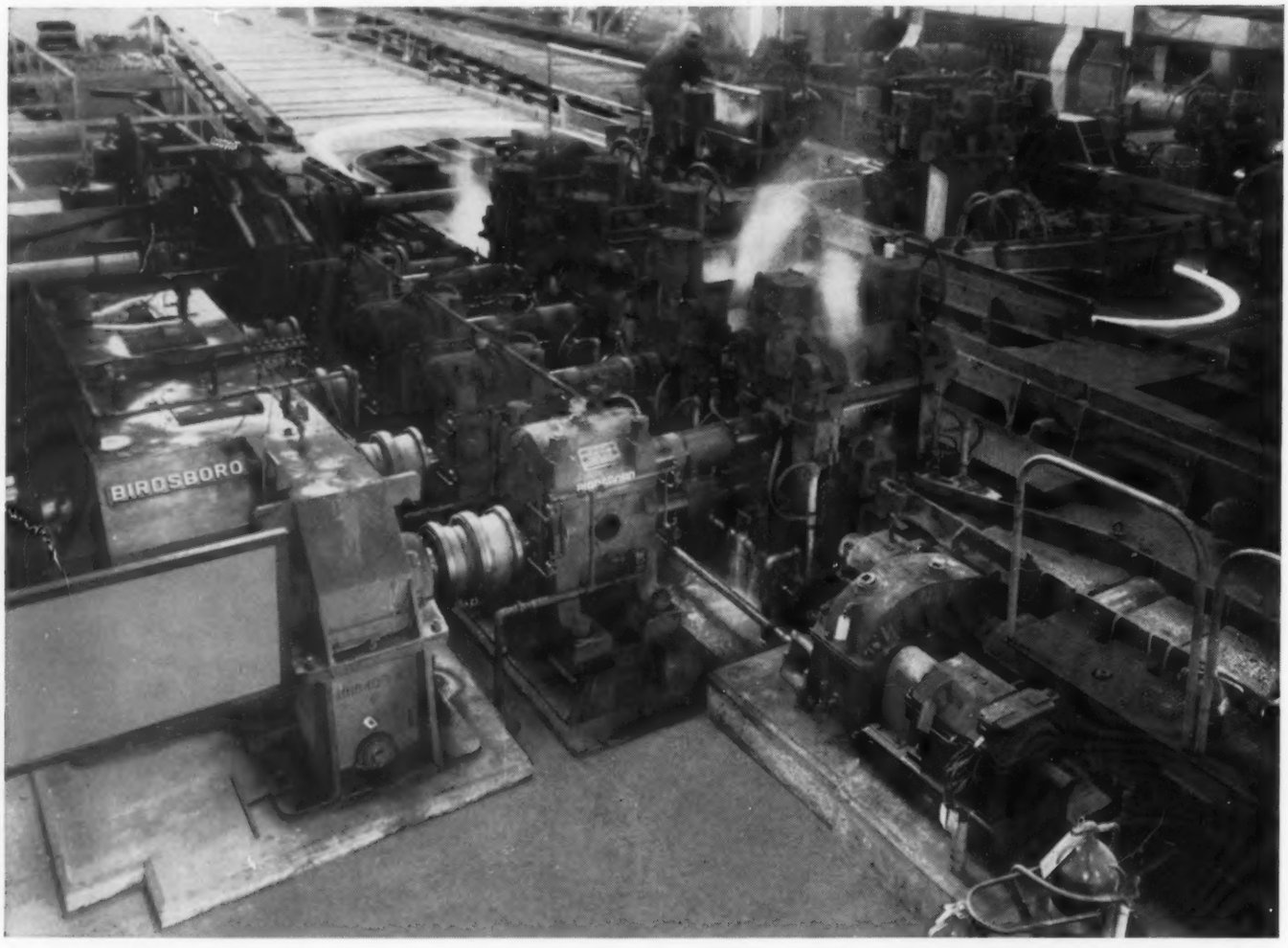
First mill designed exclusively

to direct roll electric steel

ingots of up to 1000#

into finished bars...

another **BIRDSBORO** *"first"*



RM54-60

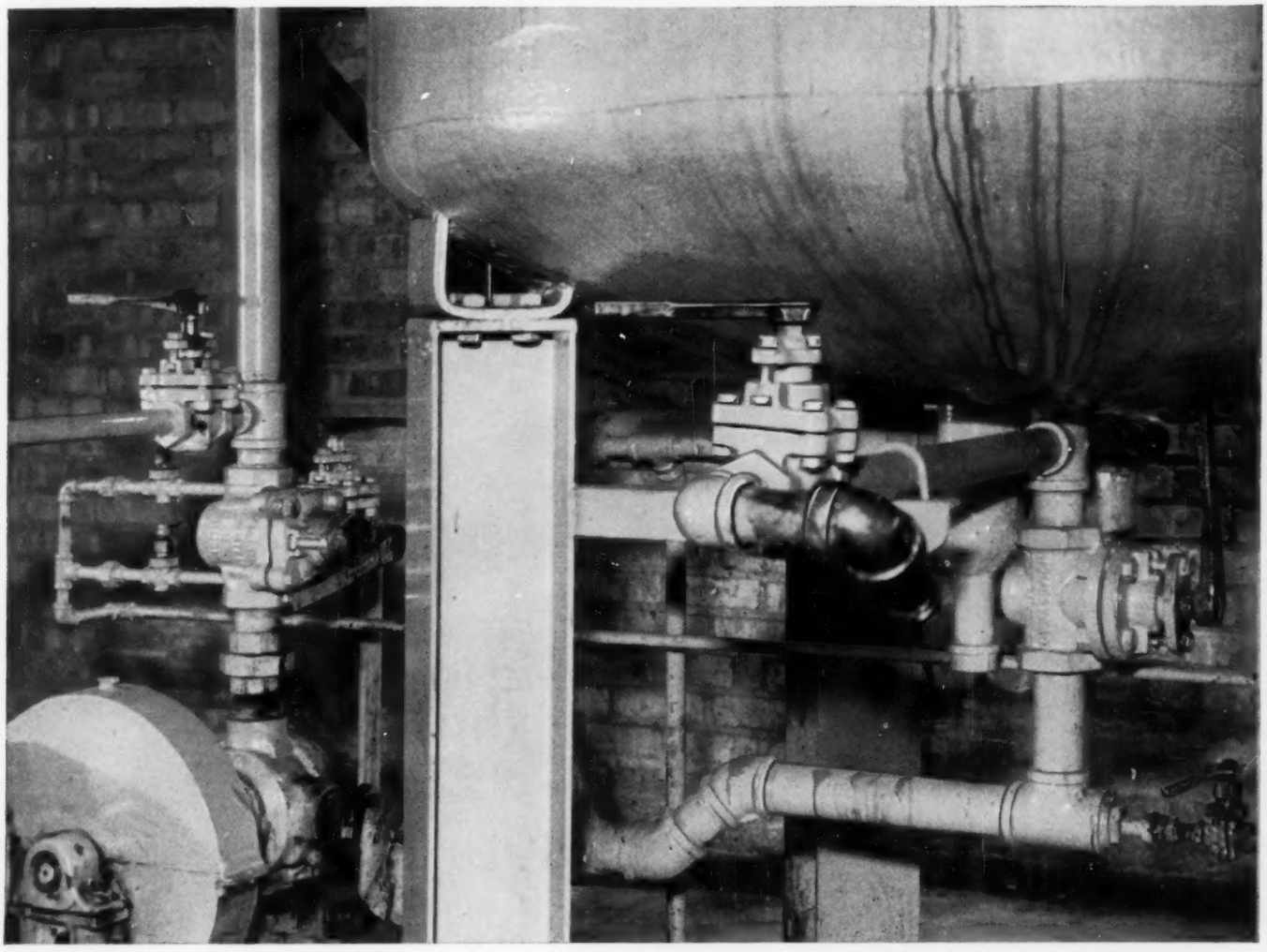
BIRDSBORO

CORPORATION

STEEL MILL MACHINERY • HYDRAULIC PRESSES • CRUSHING MACHINERY • SPECIAL MACHINERY • ROLLS • ELECTRIC STEEL CASTINGS: Carbon, Low Alloy and STAINLESS STEEL

POSITIVE FLUID CONTROL AT LOWER COST PER YEAR

is yours with Homestead® Cam-Seald Quarter-Turn Valves. The Homestead CAM is the key to the simplicity and effectiveness of these valves. The cam



limits full operation to a quarter-turn and automatically provides drop-tight shut-off by pressing tapered plug firmly into the valve body. This cam also holds plug and body in close contact for added protection of sealing surfaces. When you specify Homestead, you get longer valve life and dependable, low-cost-per-year service . . . proved by over sixty-eight years in all types of industry. Mail coupon for complete information.

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HOMESTEAD VALVE MANUFACTURING COMPANY
"Serving since 1892"
P. O. Box 160, Coraopolis, Pennsylvania

Please send Reference Book 39-2 and prices on all types of Homestead Cam-Seald Valves. 160

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Company.....

Address.....

City.....Zone....State.....

DELROYD

WORM GEAR SETS

Check these advantages:

- Involute helicoid thread form (strongest thread form made)
- Centrifugally cast gears
- More horsepower per dollar

Delroyd units are manufactured in a modern plant devoted specifically to the production of worm gearing—a plant which has one of the largest thread milling and thread grinding capacities in the United States. Because we use this exclusive precision machinery, the most exacting testing techniques and highly skilled workmanship, you are assured of quality and service associated with the leading specialists in worm gearing.

Delroyd provides the widest range of sizes and ratios, and offers complete interchangeability of parts. Whether you specify worm gear sets or worm gear speed reducers, you are assured of the finest quality obtainable.

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DE LAVAL-HOLROYD INC.

TRENTON 2, NEW JERSEY

an affiliate of De Laval Steam Turbine Company

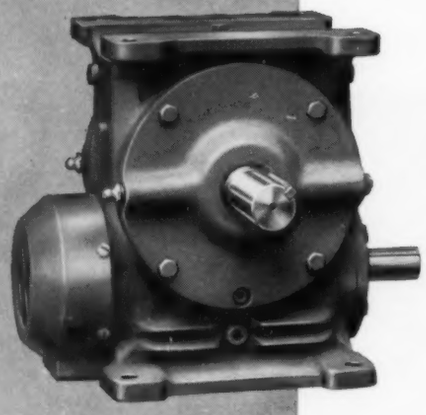
DELROYD

WORM GEAR SPEED REDUCERS

FAN COOLED RIBBED CASES

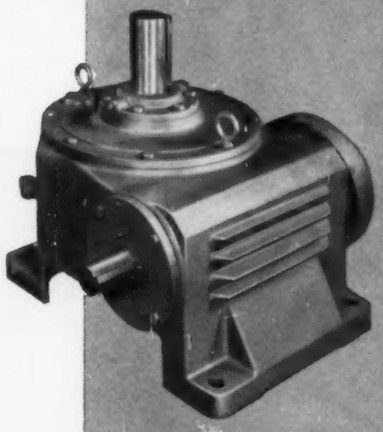
Widest range of ratings available—from .05 HP, 1⅛" center distance to 1050 HP, 36" center distance—in single and double reduction units

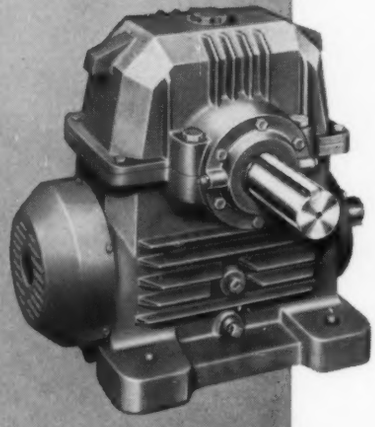
Prompt delivery from stock—all units through 12 inch center distance



TYPE D
Verso Unit
Adapts to any mounting requirement
Ratios:
5:1 to 70:1
Horsepowers:
.062 to 13.5
Center distance:
2½" to 4"

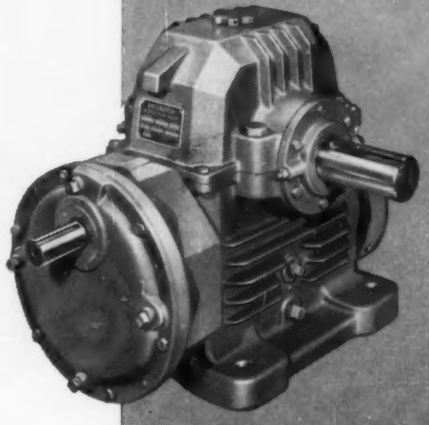
TYPE V
Vertical single reduction
Shaft up or down
Ratios:
5:1 to 70:1
Horsepowers:
.062 to 150
Center distance:
5" to 12"

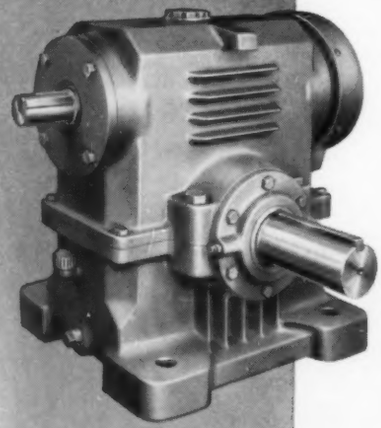




TYPE B
Horizontal single reduction
Bottom drive
Ratios:
5:1 to 70:1
Horsepowers:
.062 to 150
Center distance:
5" to 12"

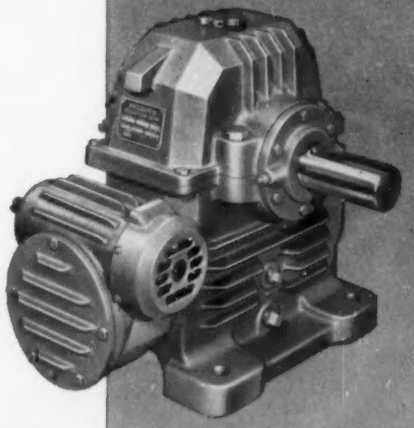
TYPE HB
Horizontal helical-worm
Right angle drive
Ratios:
15:1 to 355:1
Output torque:
2460 in. lbs. to 135000 in. lbs.
Center distance:
3½" to 12"





TYPE T
Horizontal single reduction
Top drive
Ratios:
5:1 to 70:1
Horsepowers:
.062 to 150
Center distance:
5" to 12"

TYPE DB
Horizontal double-worm
Parallel input and output shafts
Ratios:
75:1 to 4900:1
Output torque:
4170 in. lbs. to 135000 in. lbs.
Center distance:
3½" to 12"



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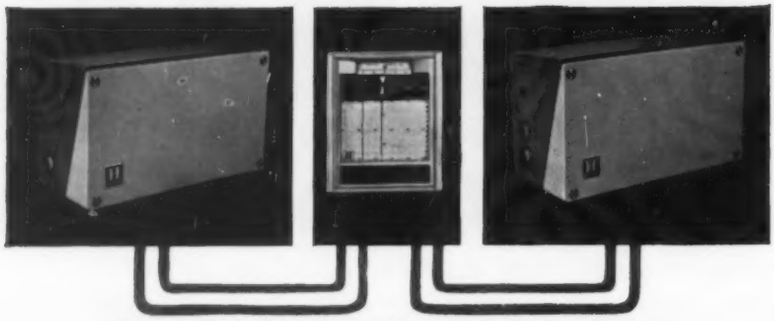
DE LAVAL-HOLROYD INC.

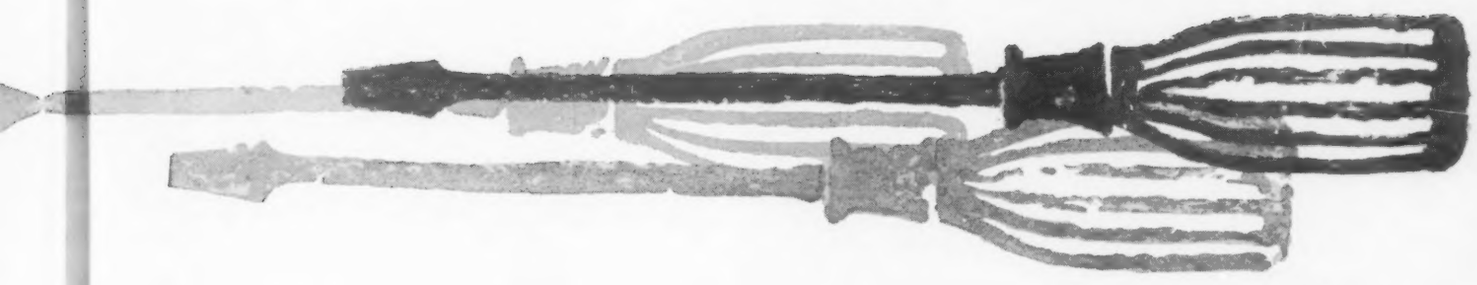
TRENTON 2, NEW JERSEY

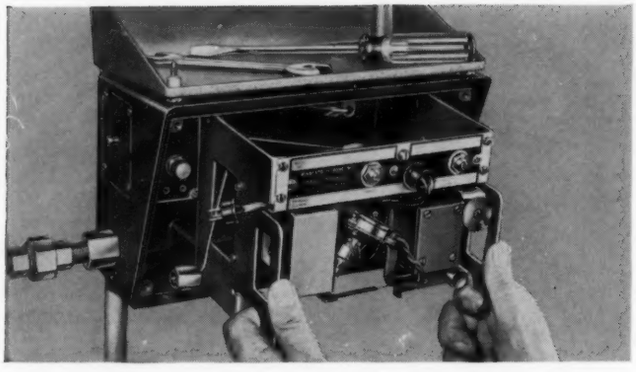
an affiliate of De Laval Steam Turbine Company



***ElectriK Tel-O-Set*—the true 2-wire system**

NO STAND-BY SUPERVISION





No stand-by supervision needed when you install an *ElectriK Tel-O-Set* Control System. Installation crews never have to open an instrument cover to hook up the line . . . instrument crews never have to touch an outside line to service an instrument.

It's all in the *Tel-O-Set* connection system. All process connections are entirely isolated from the inside of the instrument case. Installation crews can mount, pipe, and wire the various *Tel-O-Set* instruments without removing the cover. Instrument chassis can be removed for servicing without breaking any external process or electrical connection. Standardized parts, together with extensive use of quick-connect and plug-in design, minimize downtime and reduce spare parts inventory.

And there's more to the *ElectriK Tel-O-Set* economy story. Specifically, there's no external power required at any field-mounted *Tel-O-Set* instrument. Line power connection is made only at the receiver. Two-wire d-c transmission reduces installation costs and eliminates shielding problems. Also, the 4-20 milliamp signal range of the system gives a live zero and permits the use of the most reliable transistors available. The d-c signal can be fed into data handling systems and millivolt-actuated instruments . . . can be easily transduced to a standard 3-15 psi pneumatic signal to operate existing pneumatic systems.

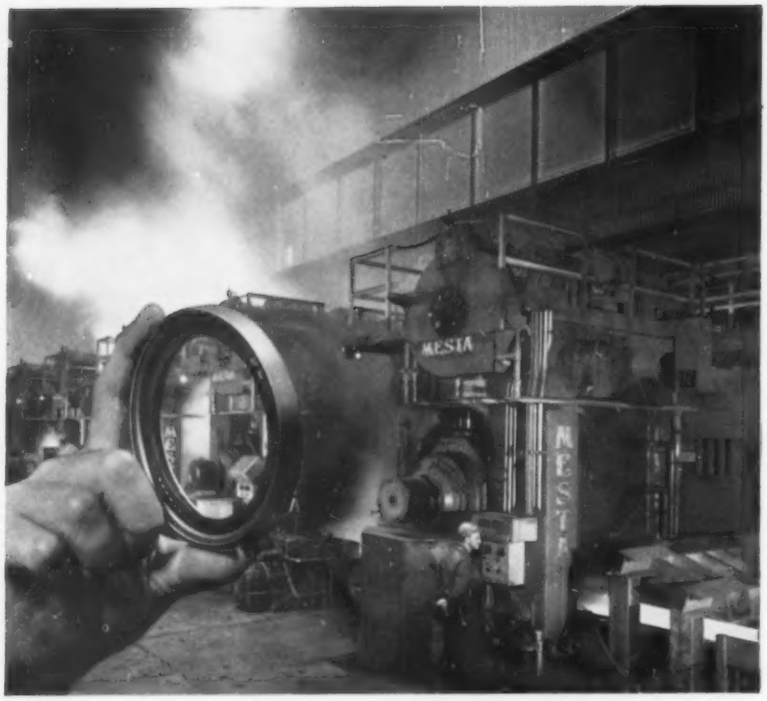
Take a new look at your control problem with the *ElectriK Tel-O-Set* System in mind! Get the complete economy story from your local Honeywell field engineer. Call him today . . . he's as near as your phone. MINNEAPOLIS-HONEYWELL, 21 Penn Street, Fall River, Massachusetts.

Honeywell

H HONEYWELL *First in Control*

SINCE 1885

ENGINEERED OIL SEALS for Steel Mills

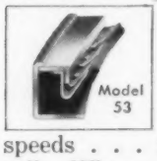


Garlock KLOZURE Oil Seals protect vital bearings from damage, add to efficiency of new Jones & Laughlin punch card-operated continuous mill at Aliquippa, Pa.

Jones & Laughlin Steel Corporation specifies Garlock KLOZURE* Oil Seals to protect important bearings on new punch card-operated mill at Aliquippa.

At dozens of vital locations on the 44″ 4-Hi Continuous Mill—approach and runout tables, vertical edgers, coilers, rotary crop shears—the Garlock KLOZURE Oil Seals perform a double duty. They stop leakage of lubrication from the bearings, prevent harmful scale, spray, dirt from getting to the bearings.

In wide use today throughout the steel industry, Garlock KLOZURE Oil Seals are available in a wide range of designs. For example, Model 142, a face-type KLOZURE, is designed to seal surfaces perpendicular to shaft . . . keeps water splash and scale out of bearings at the shoulder of mill rolls. Models 64 and 82 are applied to large shafts at normal or high speeds . . . ideal for protecting bearings on back-up and work rolls. Model 53 withstands temperatures up to 250°F at normal or high speeds . . . recommended for table rolls. Where equipment can't be dismantled easily, Models 21 or 23 Split-KLOZURES are the choice.



Like Jones & Laughlin, many of the large steel producers are enjoying the advantages of Garlock KLOZURE Oil Seals. For instance, all KLOZURES are oil and grease resistant . . . impervious to water, mild acids, alkalies . . . non-abrasive . . . withstand temperatures from −40°F to +250°F. For extreme conditions, Garlock furnishes sealing elements resistant to practically any fluid, and serviceable as high as +500°F.

Enjoy these same benefits. Talk to your local Garlock representative about high-quality KLOZURE Oil and Grease Seals. Call him at the nearest of

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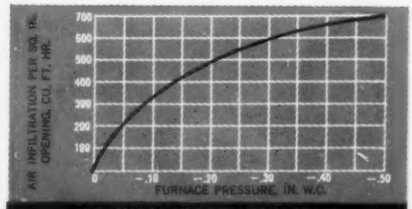
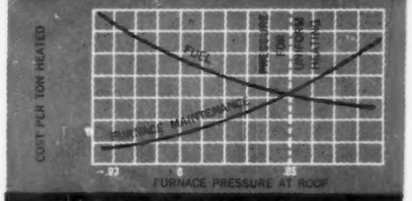
*Registered Trademark

Why **furnace pressure control** should be considered the primary combustion control on heating and melting furnaces



The effect of negative furnace pressure on air infiltration.



The effect of furnace pressure on fuel cost and furnace maintenance.

When a negative pressure exists inside a furnace, appreciable quantities of air pass through the walls and openings of the furnace structure. Actual tests have shown that even in an apparently tight furnace the amount of air infiltration can be as high as 40% of the total air required for combustion.

Thus, uncontrolled air infiltration can completely negate the function of accurate fuel-air ratio control. It leads to fuel waste, uneven and irregular heating, excessive cooling of the furnace, and flame impingement on the contents and walls.

On the other hand, uncontrolled high furnace pressure causes undue heat loss through the furnace walls and openings, the possibility of dangerous blow-outs when doors are opened, and high refractory maintenance cost.

In a properly designed furnace, the furnace pressure that is best for effective heating or melting is also the pressure that provides an optimum relationship between fuel costs and maintenance costs. Precise control of furnace pressure at this one best value is a first necessity for efficient operation.

...and why **GPE Controls** can bring more experience than any other control builder to furnace pressure control applications

GPE Controls Hydraulic Pressure Controller. Thousands of these units are now providing precise pressure control on heating and melting furnaces of all kinds.

GPE Controls Electronic Furnace Pressure Transmitter. Electrohydraulic control system combines advantages of electric transmission and hydraulic operation.

Two generations of heating and melting furnace operators and builders have relied on GPE Controls for furnace pressure control. GPE Controls developed the concepts that made furnace pressure control practical.

The pressure range of a GPE Controls furnace pressure controller is -0.05 to $+0.15$" w.c. Accuracy of $\pm 1\%$ is equivalent to holding the "zero pressure" level of the furnace within 3" vertically—the degree of accuracy that GPE Controls equipment is designed to provide.

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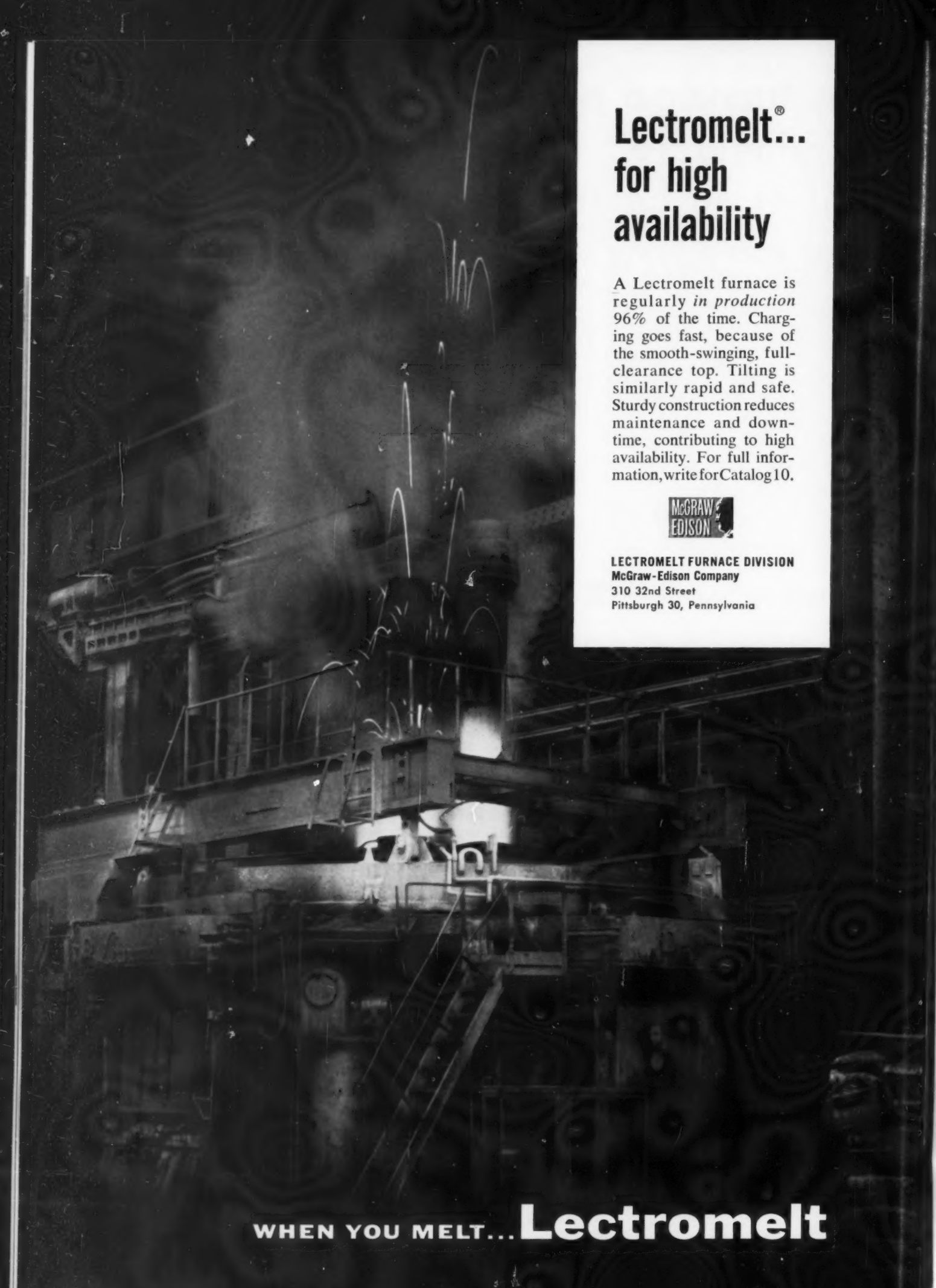

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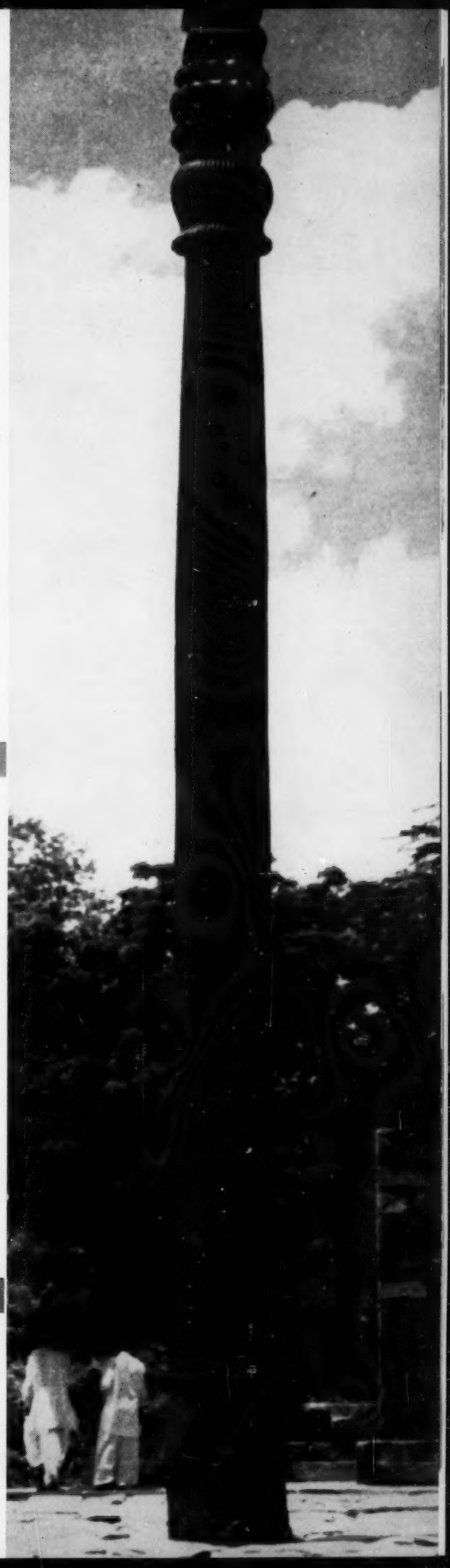
WHEN YOU MELT... Lectromelt

Observations of the Steel Industry in India and Japan

by JOHN L. YOUNG,
Vice President—Engineering Technology
United States Steel Corp.,
Pittsburgh, Pa.

An exciting and tremendous expansion program is underway in all parts of the world . . . . both Japan and India have large active programs.

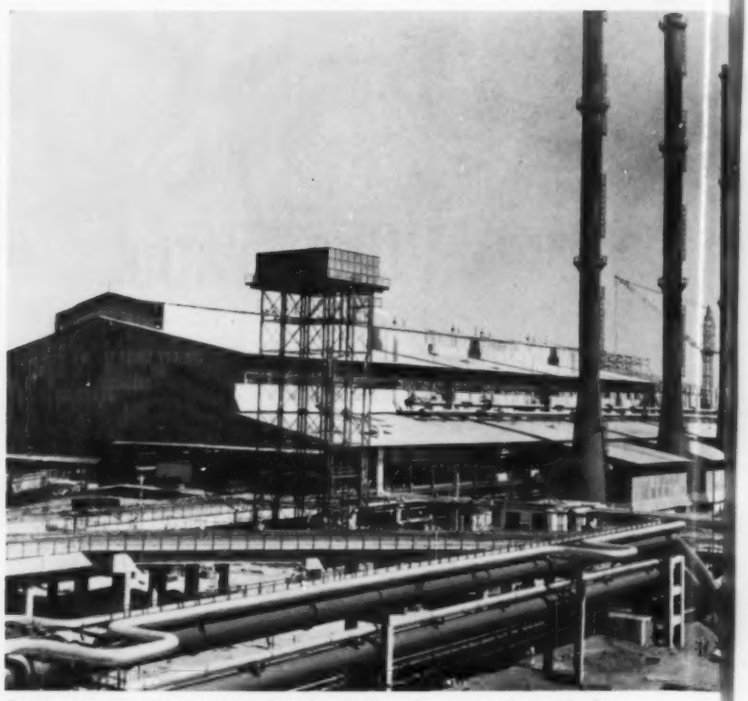
FOR the past several years, the steel companies in America have been training a number of young Indian technical graduates for management positions in two of the three new Government-controlled steel plants in India. As of September, 1959, approximately 300 had been trained out of a total obligation to train 600, at the rate of about 100 per year. In the fall of 1959 a representative of Hindustan Steel Company Ltd., the Government-controlled steel company, was in the United States. He suggested to the American Iron and Steel Institute, the sponsoring organization, that a delegation go to India to study the results of the training so far and to make recommendations for training the remaining group. As a result of the discussion, a



The Iron Pillar, in Delhi, India, is considered one of the wonders of the world. Constructed in the Fourth Century, A.D., it is a solid shaft of wrought iron 22-ft high, 16 in. in diameter and weighs six tons. Uncorroded by 1500 years of exposure to the elements, it stands as a remarkable example of ancient India's metallurgical skill. ▶

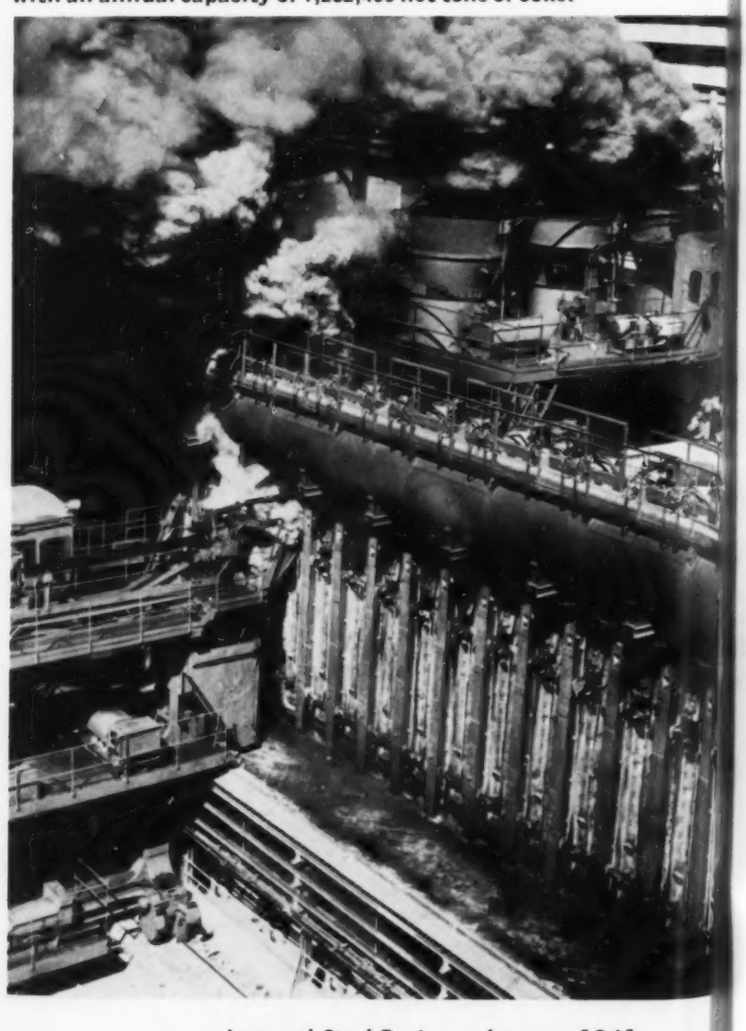
The 46-in. bloomer at Bhilai is similar to U. S. mills. It can roll 24-in. square, 5½ ton-ingot down to 8 x 8 in. in 15 passes. Mill has ten holes of pits.

The continuous billet mill of the horizontal-vertical type is very similar to the mills built at National Tube's Lorain works in late 1948. View here is from a 4-stand, 20-in. mill at the entry end looking at the delivery end of the 6-stand, 28-in. mill at Bhilai.



At the time of the visit, three of the six open hearth furnaces were built. Shop at Bhilai will eventually have six 275-net ton open hearth units and will be rated at an annual capacity of 1,120,000 tons.

Coke plant at Bhilai has three batteries of 65 ovens each with an annual capacity of 1,282,400 net tons of coke.



delegation was selected. In addition to the writer, as head of the delegation, the group included:

Stephen C. Blickenstaff, Director, Program INSTEP, Carnegie Institute of Technology
Paul P. Hubert, President, Crucible Steel International, S. A.
William P. Jones, Assistant Vice President—Personnel, United States Steel Corporation
Merle R. Thompson, Chief, Foreign Relations Department, American Iron and Steel Institute

For some time, the Japanese Iron and Steel Federation had suggested to the American Iron and Steel Institute that a delegation be sent to Japan to have a "look-see" of the Japanese steel industry. It was therefore decided that the delegation would stop off in Japan for eight days enroute to India. The delegation then spent five weeks in India.

This presentation will deal primarily with Japan and India and all figures will be expressed in net tons. However, in passing we should mention China.

The iron and steel industry in China is growing at a very rapid rate. The most recent figures indicate that in 1959 China produced 14,630,000 tons of ingots. In 1960, they expect to produce over 20,000,000 tons of ingots and over 30,000,000 tons of pig iron. By 1965, they estimate their ingot production at around 39,000,000 tons and by 1975 about 50,000,000.

The most recent figure also includes North Korea with about 7,000,000 ingot tons for a grand total of 57,000,000 tons of ingots for the two countries by 1975.

It is also understood that the Chinese now have open hearth furnaces up to 660 tons and blast furnaces producing well over 2000 tons a day.

In 1959, Japan produced 18,330,000 tons of ingots. At the present time the Japanese industry is running at the annual rate of about 26,500,000 tons. By 1970, they estimate their production at around 53,000,000 tons of ingots. It is hardly necessary to comment further on these two sets of figures. They speak for themselves.

The iron and steel plant facilities in China are primarily of Russian design whereas those in Japan are primarily of American design.

In 1949, China produced about 174,000 tons of ingots. This was before the start of their first Five Year Plan in 1952. They are now in their second Five Year Plan, which ends in 1962.

Japan's production in 1950 was 5,325,000 tons of ingots.

The 1959 ingot production in Japan resulted in 13,085,704 tons of rolled products, of which 1,531,882 tons or about 12 per cent was exported. At the same time Japan imported 341,019 tons or about 2½ per cent of their own productive capacity.

At the present time Japan is importing about 75 per cent of their iron ore. As their productive capacity increases, this percentage will naturally increase because of the limited amount of domestic ore. China apparently has a great reserve of high grade iron ore. The ore imported by Japan is primarily from Malaya, Goa, India and the Philippines, with only a small amount from the United States. Recent agreements with India will increase the importation from Indian ore to around 9,000,000 tons by 1965.

As to coal, at the present time about 50 per cent is imported and this likewise will increase as the steel plant productive capacity increases. In this case, most of the coal is imported from the United States. Here again, China has ample reserves of high grade coking coal.

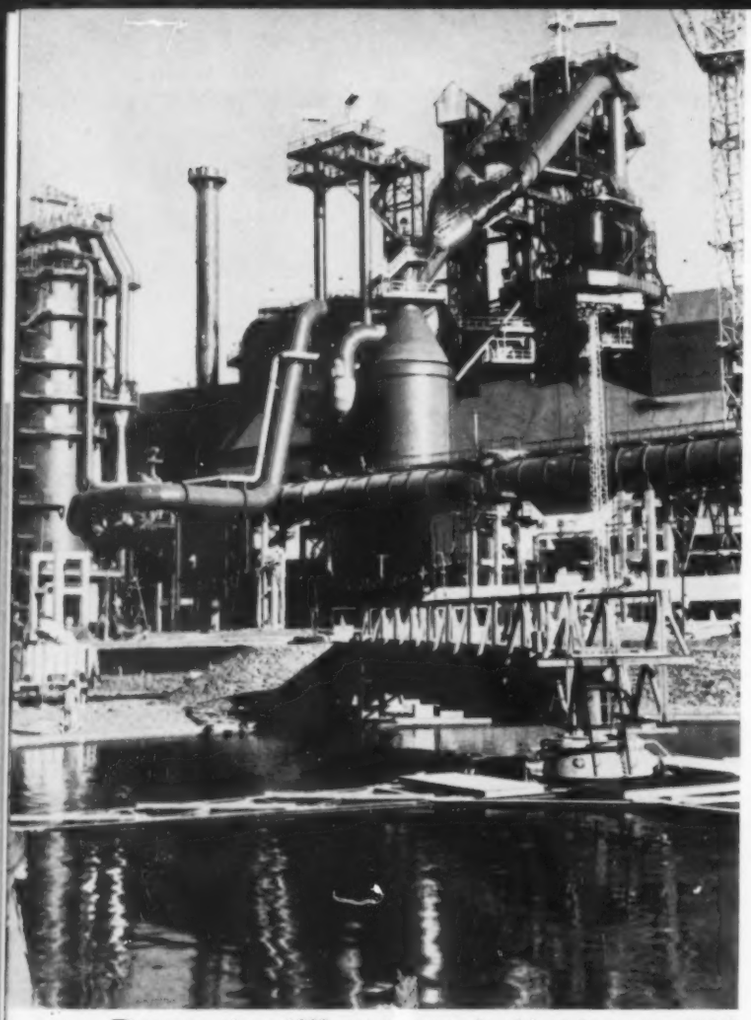
At the present time in Japan, sintered ore represents about 50 per cent of the blast furnace charge and their coke ratio is among the lowest in the world.

Nearly 90 per cent of the steel now produced in Japan utilizes oxygen either in the open hearth or in top blown oxygen converter vessels. At the present time they are averaging about 640 cu ft of oxygen per ton of steel, but in some open hearth shops they are now up to 1300 cu ft per ton.

In 1943, there were 35 blast furnaces in Japan but in 1945 after the war, only nine were left operable. In 1959, there were 30 blast furnaces in operation and several more large furnaces under construction. During the next ten years they plan to construct 30 more blast furnaces.

The first six years after World War II, from 1945 to 1950, were used mostly in restoration of productive facilities in Japan. Their first modernization program started in 1951 and was a Five Year Plan. This program included many new mills, new iron and steelmaking facilities, modernization of plate and sheet mills, and construction of the Kawasaki Steel Co. plant at Chiba as a completely integrated works for flat rolled products.

The open hearth ladles have an unusual shape. Note the flared sides.



There are three 1300-net ton per day blast furnaces which will have an annual rated capacity of 1,243,000 net tons. The three furnaces have 22-ft hearths and are equipped for high top pressures up to 20 psi. Hearth diameter is small since furnaces were built to match existing Russian drawings, thus expediting construction scheduling at Bhilai.

In 1954, the steel demand fell off somewhat and the program was slowed down. However, it was rejuvenated in 1956 when the expansion program started again. During this period, the first LD furnaces were installed with two 45-net ton vessels at Nippon Kokan, two 55-net ton vessels and two 65-ton vessels at Yawata Steel. These six vessels were in operation by 1959, and during this period four completely integrated steel plants have been built on new sites, most for flat rolled products such as plate and strip.

The following information compares Japan and India.

Japan has about 93,000,000 people (about half the population of the United States) in an area smaller than the state of California.

India has 415,000,000 people (one-seventh of the world's population) in an area about two-fifths the size of our continental States.

As to raw material, Japan has some coking coal but now must import about 90 per cent of its iron ore.

India is blessed with some of the finest iron ore in the world, averaging about 63 per cent Fe and in unlimited quantity. They estimate about 15,000,000,000 tons of coal in reserve, of which about 2,000,000,000 is of coking quality.

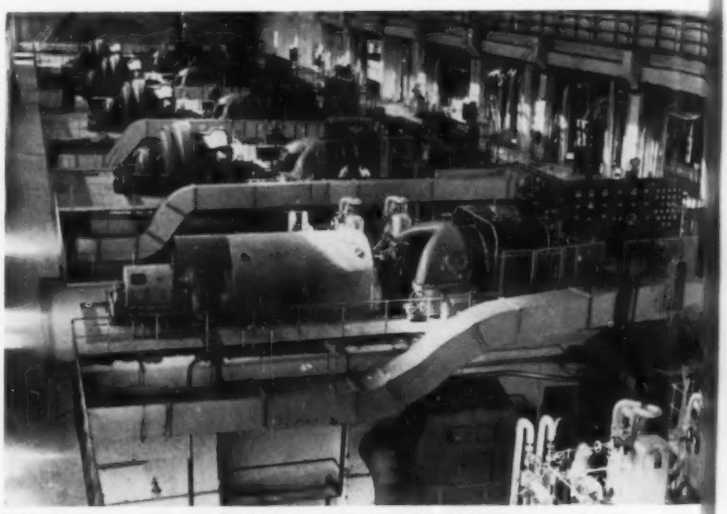
Japan's domestic market is growing at a very rapid rate. Their planning indicates that about 12 to 15 per cent of their steel product will be for export, at least for the next five or ten years.

The Indian market potential is enormous. No one knows what it is. There is every indication that the full capacity of the present five major steel plants can be used without any question and India will still import quite a bit of steel. Studies indicate that India can use all of its own produced steel for the next ten to fifteen years even if they double or triple the capacity.

Now, as to wages, this is one of the most difficult items to evaluate because of the many fringe benefits in both countries, that is, Japan and India.

It has been stated that the average hourly wage in Japan is about one-seventh the hourly wage of the American steel industry. However, when all fringe benefits are considered, it is possibly closer to one-fifth. The employment in the newly constructed plants indicates that the man-hours per ton are approaching those of the American industry. However, the cost of raw materials required for these steel plants to some extent offsets the lower labor rate.

It has been stated that the total hourly employment



The blower plant at Bhilai consists of four blowers and two turbogenerators.

With enough people, appreciable tonnage can still be produced by hand methods. Ore here is being hand-screened in the Rajhara hills about 66 miles from Bhilai. This mine is being mechanized to ship 2,750,000 net tons annually to the Bhilai plant of 63 per cent Fe ore.

cost in India, including all fringe benefits, is in the neighborhood of one-eighth of the American figure. In India, the number of employees compared to a similar plant in the United States is tremendous. For instance, the Tata steel plant at Jamshedpur for an annual ingot production of 2,200,000 tons has 28,000 employees in the steel plant alone.

The three new Government steel plants of Hindustan Steel Ltd. will average somewhere between 10,000 and 12,000 employees per plant for an annual ingot capacity of 1,100,000 tons.

India, with the low labor rate, even with the numbers employed, and low cost raw materials, should be one of the lowest cost producers of steel in the world, especially in the new, modern plants.

As to literacy, it is claimed that Japan now is almost 100 per cent literate.

In India, the literacy is indicated at somewhere between 10 and 20 per cent. Literacy is increasing, however, their population is also growing at the rate of about 5,000,000 a year. It is going to take a long time for India to finance the building of schools, the teaching of teachers and the establishment of an overall educational system for the younger people. In all fairness though, at the college level India has some excellent universities and technical institutes. The graduates are brilliant people.

As to transportation, the railroads of Japan are some of the best in the world.

India has an excellent railroad system, but with the rapid strides of industrialization it is not keeping pace and therefore is now the principal bottleneck in the industrial program.

Whereas Japan now has one automobile for each 378 people, they are all crowded within the cities. The streets in the cities are good but the interconnecting highways are very poor.

In India, the automobile ownership is very low. The streets in the main cities are excellent and there are a great many paved highways connecting the large centers.

As to communications, in Japan almost all phases of communications, even the telephones, are good. There are now 2.2 television sets per 100 population and 16.4 radio sets.

In India, the only good method of communication is the telegraph. There are very few radios and only one television station. That one is in New Delhi and at present is broadcasting only four hours a week to the 100 TV sets in that area. Their telephone system is not one that can be praised.

Some more interesting figures about Japan are: there are 12.4 electric refrigerators per 100 households in the Tokyo district and similarly there are 41.2 electric washers. The modern all-steel kitchen and household appliances are gaining rapid favor in Japan.

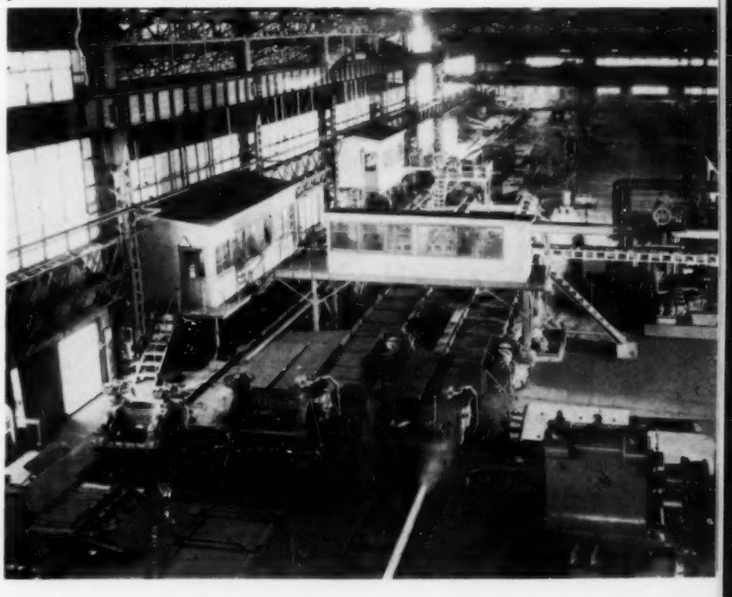
India has the lowest per capita steel consumption of any major country of the world. It is now under 20 lb per person.

Now as to the steel plant capacity of India. Two years ago the Indian annual capacity for ingots was 1,800,000 tons. The rated annual capacity of the present plants when all facilities are operating will be about 6,800,000 tons. All of these new facilities should be in operation by mid-1961. They have all been

This is open hearth shop at Chiba works of the Kawasaki Steel Co. in Japan. This shop makes extensive use of oxygen and has a consumption of about 1280 cu ft per net ton. At time picture was taken shop was running about 180 net tons per heat. It was reported that the fuel used was heavy oil, carbon monoxide gas and oxygen giving heat to heat times under four hours with 60 to 70 per cent hot metal.

Outside of shop shown in Figure 9. Rating of this furnace will be 2,400,000 net tons annually.

This bar and billet mill of the Mitsubishi Steel Co. rolls product from ½ to 8 in.



constructed under the Second Five Year Plan, which ends March 31, 1961.

The Third Five Year Plan is scheduled to start in April 1961 and indicates an increase by 1966 to about 10,000,000 tons of ingots.

Discussion

PRESENTED BY

BELA KOJA, Senior Engineer—Projects, American Steel and Wire Div., United States Steel Corp., Cleveland, Ohio

JOHN L. YOUNG, Vice President—Engineering Technology, United States Steel Corp., Pittsburgh, Pa.

Bela Koja: Since those steel plants are all of modern construction, what is the reason for the one to seven ratio in the manning of the plants?

John L. Young: The one to seven ratio mentioned is the comparative hourly wage in the Japanese steel industry to that here in the United States. Because of fringe benefits in Japan, the ratio may be closer to one to five. The figures of employment in India work out to about the same ratio.

We mentioned 45,000 to 55,000 construction workers on the site at each of the three new steel plants in India. You will find the ratio not far off for the construction of a similar size steel plant here in this country.

In the manning of the three new Indian steel plants, we mentioned that the forces would be around 12,000. That would be at least two to three times the standard force for a similar size plant here in America.

In answer to a question as to the great number of production employees, one of the members of the Indian Steel Plant management replied "You realize, we are a Government organization and as such we have a tremendous number of clerks." ▲

Available Translations

As a service to readers of the *Iron and Steel Engineer* a list of translations from foreign articles is being printed intermittently. Articles selected for this listing will be those of primary interest to the American steel plant operator. The papers may be obtained from the British Iron and Steel Industry Translation Service, The Iron and Steel Institute, 4 Grosvenor Gardens, London, S.W. 1, England. All correspondence concerning price, ordering and so forth should be directed to that address.

1490 GELEJI, A., et al. "Tests to Determine Roll Forces and Power Requirements in a Mannesmann Oblique Rolling Mill," *Stahl u. Eisen*, 1959, Sept. 17, pp. 1352–1356. Tests to study roll force and power requirement in a Mannesmann oblique rolling mill were undertaken by the department for the design of steelworks plant and for the plastic working of metals of the Hungarian Technical University for heavy industry. The mill was driven by a three-phase motor (1650 kw). Strain gages were mounted at seven points on the mill and the pressures occurring ascertained in a large number of tests. Loads on the motor were recorded at the same time by means of oscillograms. The test data provide information on the effect on the rolling process of the following: (1) billet dimensions, (2) position and shape of plug and its method of operation (rotating or stationary), (3) rolling temperature, and (4) shape and surface condition of the pierced blooms.—Author's summary

1502 ANON. "Selection of blowers for cupolas," *J. d'Inf. Tech. Ind. Fonderie*, 1959, Jan., pp. 1–3.

1560 FUNKE, P.: "Fatigue Cracks in Composite Back-Up Rolls for Cold Mills," *Stahl u. Eisen*, 1959, Oct. 1, pp. 1430–1431.

1439 WARTMANN, R.: "Calculation of the Reheating Process of Steel Ingots and Comparisons with the Results as Measured," *Stahl u. Eisen*, 1959, May 14, pp. 703–711. The problem of reheating large steel ingots without inducing too large temperature differences between surface and core is treated mathematically. The results of the numerical calculations carried out on computers are in good agreement with experimental results. Abstract *J.I.S.I.*, 1959, Nov., p. 321c.

1628 KLOTH, W.: "Stress field as a fundamental tool in crane design," *Stahl u. Eisen*, 1960, Feb. 4th, pp. 159–164. (Knowledge of stress fields as a fundamental requisite in crane design and design calculations. Reduction in crane weight and greater economy of materials in use. Local design in the light of specific stress fields. Determination of stress fields. Examples on the proper use and evaluation of stress fields. Avoidance of unfavorable stress peaks and of stress peaks defying calculation on a welded nodal point with an open profile. Design of nodal points of rectangular hollow sections and gusset plates, deviating only slightly from calculated values. Stress peaks caused by local welded-on straps, thereby doubling the stress level. Impossibility of expressing stress distribution in fields containing stiffening plates in mathematical form.)

1503 MUNCH, G.: "Methods and apparatus for measuring the thickness and width of hot and cold rolled strip," *Stahl u. Eisen*, 1959, Oct. 29, pp. 1601–1615.

1605 BRANDI, H. T., et al.: "Blast Furnace Lines and Design of Charging Equipment," *Stahl u. Eisen*, 1960, Jan. 21, pp. 65–73. (Historical development. Calculation of inner lines. Design of outer lines. Design of charging equipment. Author's contents list.)

1610 DRUZHININ, V. P.: "Design of the Continuous Casting Plant at Novo Tula." (The author gives details of the vertical continuous casting machine at Novo Tula, south of Moscow, for producing 24 × 8-in. slabs at speeds of up to 7 fpm. Conditions for obtaining good surface and structure are outlined.)

Algoma's 46-In. Blooming and Plate Mill

The latest part of Algoma's expansion at Sault Ste. Marie is a mill with innovations in design which are well worth consideration by the 1,000,000 to 2,000,000-ton steel plants.

ENGINEERING AND DESIGN

by J. L. LAIDLAW
Manager of Engineering and Construction
Algoma Steel Corp., Ltd.
Sault Ste. Marie,
Ontario, Canada

IN 1956 it was evident that to keep Algoma's finishing mills at maximum production rates, following several years of continuous expansion and modernization, that additional ingot and blooming capacity was necessary. The foreseeable tonnage of semifinished steel required, however, fell far short of the capacity of another blooming mill.

Market surveys revealed that considerable tonnages of steel plate were being imported into Canada each year, and the demand indicated that Algoma could profitably enter the plate market providing one mill could be built that would roll plate as well as ingots.

After complete and comprehensive studies had been made, it was decided to install a powerful mill with capacity to meet existing and future blooming requirements, and by interchangeable 4-high filling of the same stand produce a substantial tonnage of high quality steel plate. The mill was designed for the following products:

1. Slabs for plate production.
2. Blooms for rerolling in other mills.
3. Beam blanks for a 30-in. standard structural mill and a 50-in. universal beam mill.
4. Tube rounds from 7 to 10-in. diameter.
5. Sheared plate 104-in. wide from $\frac{1}{4}$ to $\frac{3}{4}$-in. thick and up to 80 ft-0 in. long, produced on the mill from slabs previously rolled.
6. Heavy plate beyond $\frac{3}{4}$ in. thick for flamecut finishing.

The mill was ordered in December, 1956, for 20-month delivery and scheduled for operation by the end of 1958, however, a two month mill builder strike postponed the startup until February 23, 1959.

The mill building is 1740 ft long, has a crane span of 85 ft-6 in., slab yard 515-ft long with a crane span of 105 ft-6 in.

In addition to the mill itself a new ingot stripping building was constructed, having two stripping cranes of 200 and 400-ton capacity, the 200-ton being an existing unit relocated on the new site.

Three new batteries of soaking pits were installed in the existing soaking pit area, and a new slab reheating furnace provided for reheating slabs for 4-high plate rolling.

The general layout of the mill is shown on Figure 1.

SOAKING PITS

The soaking pit building, Figure 2 serving the existing 44-in. blooming mill was extended, three new batteries of soaking pits and a pit crane installed. Each battery consists of three holes 24 ft-0 in. x 9 ft-0 in. x 14 ft-0 in. deep, capable of heating ingots in the following sizes:

1. 16 Ingots 27 x 27 x 80 in.
2. 12 Ingots 31 x 35 x 80 to 90 in.
3. 8 Ingots 30 x 62 x 96 in.

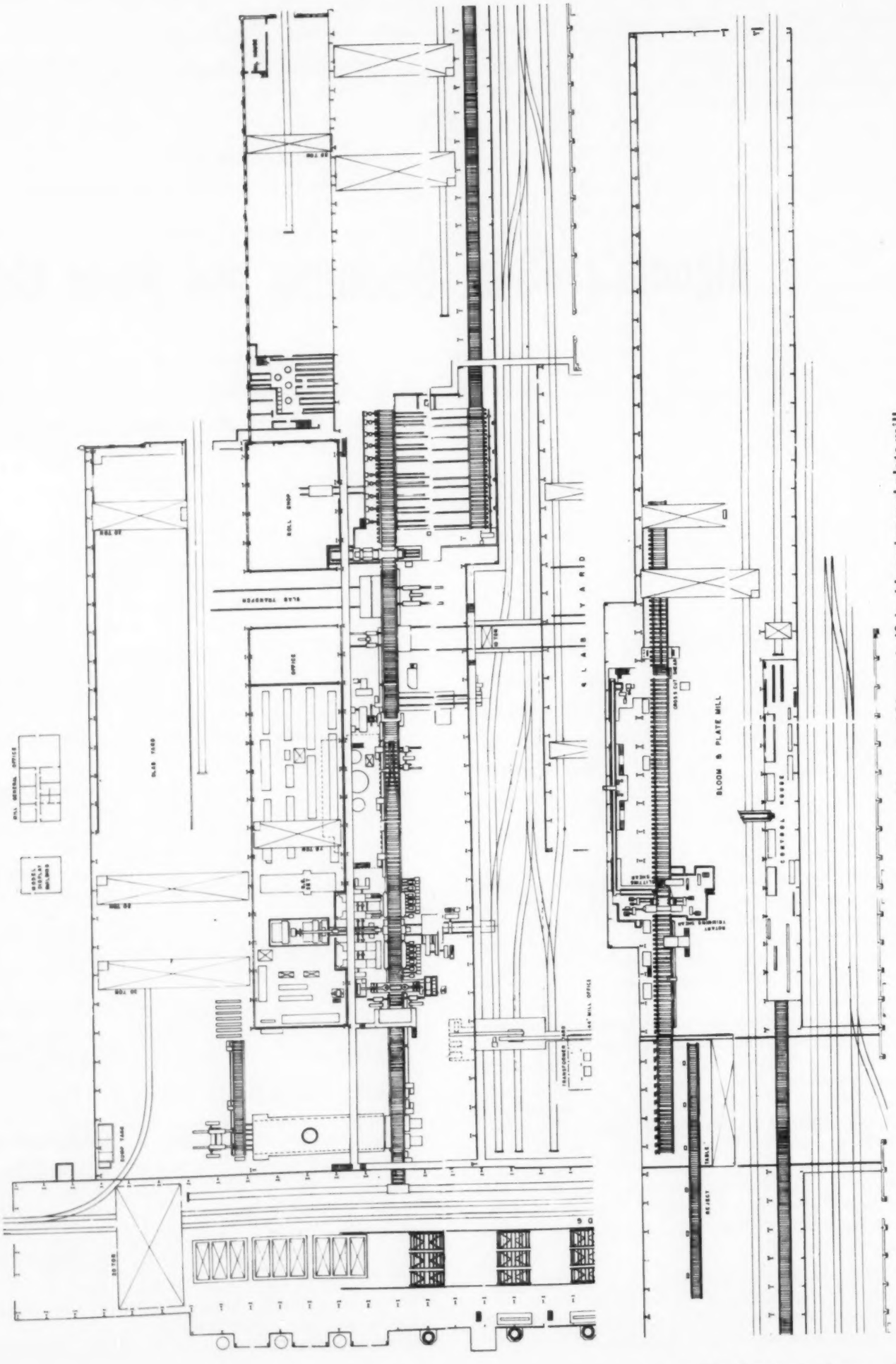


Figure 1 — General layout of Algoma's 46-in. blooming and plate mill.

in an estimated time of 13 to 14 hr from cold to rolling temperature. The pits are fired with a mixture of blast furnace and CO gas, the maximum fuel metering rate per pit being 30,000,000 Btu per hour, and each pit has one burner mounted on the top end wall.

Each pit is straddled by a pit cover crane on its own runway operated automatically from the pit crane or manually from the pit floor.

Full automatic control was installed with gas pressure control, Btu control, temperature control, fuel-air ratio control, pressure control and automatic gas shut off. A hydraulic pump is supplied for operating the various control valves, etc., but in the event of automatic failure, all controls can be manually operated. The pits are giving satisfactory service and meeting all requirements to date.

Figure 2 — Three new batteries of soaking pits and a pit crane were installed.

SLAB REHEATING FURNACE

The slab reheating furnace has three-zone firing by CO gas or Bunker C fuel oil and is of the continuous pusher type and rated for a maximum production of 140 tons per hour. The effective hearth length is 85 ft-0 in. and the over-all chamber length is 90 ft-6 in. long by 23 ft-9 in. between side walls. The furnace is dimensioned to heat a range of slabs of the following thickness and rate per hour:

1. 4-in. thick—125 tons per hour.
2. 6-in. thick—140 tons per hour.
3. 7-in. thick—130 tons per hour.
4. 10-in. thick—108 tons per hour.
5. 12-in. thick—90 tons per hour.

The furnace is equipped with metallic recuperators on top to preheat 37,200 cfm of air to 780 F assuming the flue gases entering the recuperator chamber are at 1800 F, and the heat input to the furnace is zoned as follows:

Soak zone	8 Burners	7,300,000 Btu
Top zone	7 Burners	16,400,000 Btu
Bottom zone	4 Burners	16,400,000 Btu
Holding burner	2 Burners	3,500,000 Btu

This makes a total burner rating of 245,800,000 Btu's with an estimated fuel consumption at maximum firing rate for 140 tons of steel per hour, with recuperated air at 780 F of 445,000 cfhr of gas or 1630 gal per hr of fuel oil.

ELECTRICAL EQUIPMENT

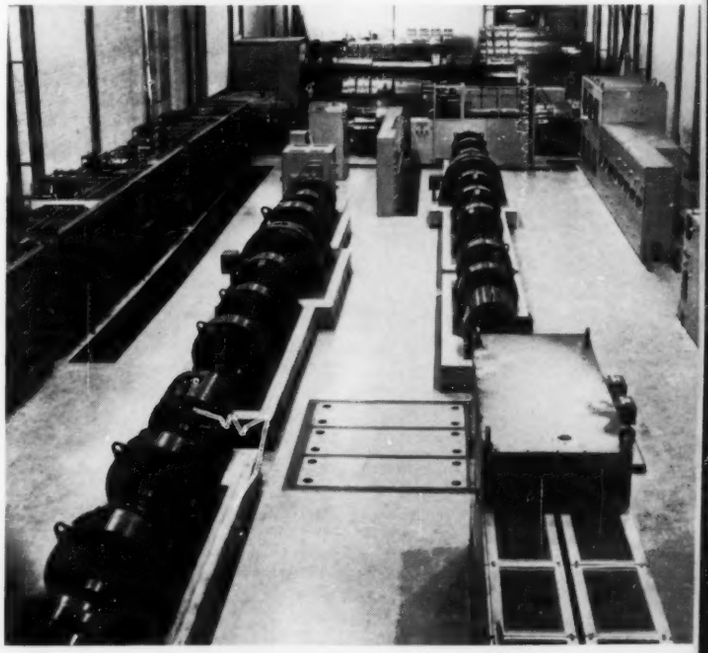
Before describing the mill equipment, it may be appropriate to first briefly review the basic electrical system.

The mill including the plate finishing line is powered by 461 motors with a total nameplate rating of 21,984 hp. The mill rolls are driven by twin motors of 4000 hp each, and the vertical edging mill has two 600-hp motors, one driving each roll. On the mill auxiliary drives there are 50 d-c adjustable voltage motors, equivalent to 4147 hp, and 158 d-c constant potential motors with a total rating of 2529 hp. The remainder are 2300 and 550-volt a-c on pumps, cranes and miscellaneous equipment.

The power for the twin 4000-hp drive motors is supplied by an 8000-kw flywheel motor generator set, with four 2000-kw generators driven by a 6000-hp, a-c 11,000-volt, 60-cycle wound-rotor motor. The mill is controlled up to 40-rpm base speed by armature voltage regulation, and from 40/80 rpm by motor field current regulation. For normal operation each motor is connected to two generators in parallel, but should one generator be out, the mill can still operate at capacity with three generators coupled in parallel, the changeover being accomplished by manually operated switches. The 600-hp motors on the 42-in. edger are similarly controlled except that each motor has one auxiliary generator.

Auxiliary drives on adjustable voltage are the two

Figure 3 — Some 461 motors with a total nameplate rating of 21,984 hp were needed.



edger drive motors, mill approach tables, mill front and back tables, mill runout tables, manipulators, side guards, screwdown motors and slab shear. Power for these auxiliaries is supplied by four motor-generator sets three of which are each driven by a 2300-volt, 1250-hp a-c synchronous motor and the fourth by a 2300-volt, 400-hp induction motor. The constant potential auxiliaries are supplied from a 900-kw silicon rectifier substation. The main drive, motor-generator sets and switchgear are all located in a large motor room (Figure 3).

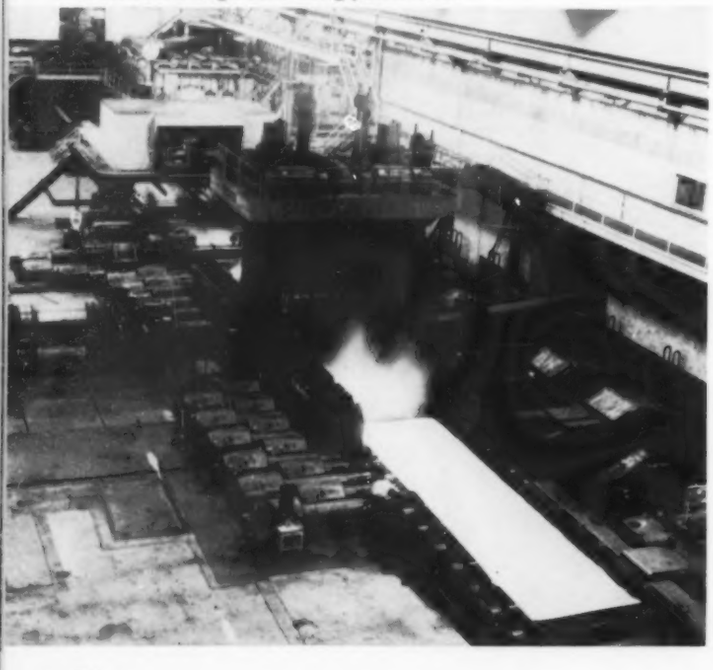
The ingot buggy travel and tilt motions are controlled remotely by carrier frequency control equipment. The travel is controlled from the pit cranes and the tilt from the mill operators pulpit. The buggy is stopped at preselected pits or mill dump table by slowdown and stop limit switches. Master switches are mounted on the buggy itself for maintenance and testing purposes.

The ingot receiving end of the mill is sequenced so that when the mill operator releases the ingot with his weigh and turn pushbutton, it automatically runs on to the ingot turn around and scale, is lifted, weighed and turned through 180 degrees, lowered and proceeds on the runout table towards the 42-in. edger. If he so desires the operator by using another pushbutton can lift and weigh the ingot only. Floor-mounted manual controls are available in an emergency for these operations.

The front and back mill tables, start, stop and reverse with the mill and are controlled by a master foot switch in the main mill pulpit. The mill approach and runout tables are operated by a separate master switch on the main pulpit control desk, but will be sequenced with the mill, provision for this having been made in the original installation.

Provision is made for automatic screwdown using an automatic control card reader, the digital output signal from the card reader is compared to the digital signal of screw position and the error regulates the screwdown control, the operator merely presses a button between passes to set the screws for the next pass.

Figure 4 — Mill stand is used either as a 2-high blooming mill or a 4-high reversing plate mill.



It is the intention step by step after the mill has been in operation for sometime and has fully trained operating crews, to automate the side guards, manipulators and tables and for plate rolling to tie the mill screws to a gamma ray thickness gage which is now in operation. Provision has been made in wiring for these steps as they become feasible, including load cells under the screws.

The 1500-ton slab shear is driven by two 375-hp motors mechanically connected through gears and electrically in series. The cut is initiated by pushbutton in the operators pulpit, and is made between 65 and 180 degrees (bottom dead center) of crankshaft angle. At 300 degrees, voltage on the motors is decreased to permit the shear to slowly move onto top dead center, at which point voltage is near zero, and brakes applied on motors. The cut sequence is automatic but jogging control is provided for forward or reverse.

The hot plate leveler, cooling bed runout spool table and plate finishing line has motor-generator sets and controls located in an overhead control room. The finishing line can be operated separately for plate finishing while the mill is rolling slabs.

These very briefly are the control features of the mill.

INGOT BUGGY

The ingot buggy has a maximum travel of 595 ft and a maximum speed of 900 fpm, although to date this speed has not been utilized. It runs on a 5 ft-6 in. gage track at right angles to the 46-in. and 44-in. mill, parallel with the old and new soaking pits and is arranged to dump ingots on both mill tables.

The traversing drive is powered by two 100-hp, d-c motors and the tilt mechanism has a 50-hp motor, all mounted on the buggy. This car is equipped with a tilting pot large enough to accommodate 50,000-lb ingots, and the bottom side of the pot in the dump position, is ribbed so that the ribs fit between the ingot dump table rolls.

TABLES

All mill tables down to the plate leveler with the exception of the individually driven front and back tables on the mill are lineshaft driven, have heavy solid rollers running on roller bearings, all of extremely heavy construction to withstand the heavy shock loads on a mill of this type and ingot size. The one exception to roller bearings is the ingot dump table which has heavy bronze sleeve bearings. Up to the slab furnace runout table the width of roll face is 72 in. and from this point on the table roll face is 114 in.

The front and back mill tables are individually driven by 36-hp d-c motors with a speed of 90/180 rpm. The rollers are alternately tapered from 18/20 x 124-in. face, can be driven in alternate opposite directions for slab turning during plate rolling.

INGOT TURNAROUND AND SCALE

An ingot turnaround and scale is provided just ahead of the slab furnace runout table. The weighing and turning of ingots at this point is fairly common practice, the turnaround being used so that ingots can be rolled butt first to ensure that maximum cutting at the shear is attained.

42 IN. VERTICAL EDGER

The edger is located about 40 ft-10 in. ahead of the mill, and between the mill and the operators pulpit. It is designed and built very low, so that while the operators can see it clearly they can also see over it, into the main stand rolls. It has a maximum opening between roll faces of 9 ft-8 in. and minimum of 2 ft-6 in. and a roll speed of 352/1110 fpm and has a separate 600-hp, d-c motor driving each roll through a reducer and bevel gears. The motor speeds are 200/600 rpm. A feed roll on both inlet and outlet sides of the edger, built into the frame is powered by a 36-hp motor at 103/206 rpm. The opening and closing screw drives are 50 hp giving a maximum travel speed of approximately 114 in. per min.

The edger is of very heavy construction and performs several very important functions. It will handle slabs up to 10 in. thick and controls width and edge finish on heavy mill edge plate. It is also used as a scalebreaker on all reheated slabs for plate rolling. Immediately behind the edger there is a 1200-psi hydraulic descaler designed in two units across the width of the table, each unit, being swiveled into a vertical position by a hydraulic cylinder, so that ingots can pass through on edge for the scalebreaking pass in the mill without dismantling the descaler heads. When being used to descale plate it can be raised out of the way in two seconds should a badly turned up plate leave the mill in the direction of the descaler.

2-HIGH 4-HIGH MILL STAND

The mill stand, Figure 4, is unique in that it is alternately a high-lift blooming mill or a 4-high reversing plate mill, either roll train being accommodated in the same stand. As a blooming or slabbing mill the rolls are 46 in. diam. x 114-in. body length and as a reversing 4-high plate mill there are 38 x 114-in. work rolls and 53 in. diam x 114-in. backups. As a blooming and slabbing mill a large filler piece is used under the bottom roll to make up for the bottom backup chocks. All roll neck bearings are parallel bore multi-row roller bearings, with suitable seals on the inside faces to prevent water or scale intrusion.

The screwdown arrangement on top of the mill is a double drive, through independent gear trains, separated by air-actuated clutches for alternate use either as a blooming or plate mill. Both drives alternately work on the same screws which are 18-in. diam. and 2-in. pitch designed for a fast high-lift mill. For blooming and slabbing, two 150-hp motors with a speed range of 460/920 rpm give a screw speed of 92/184 rpm or 15/30 fpm. For plate rolling the alternate drive is used, it having two 50-hp motors with a speed range of 550/1100 rpm, giving a screw speed of 7/14 rpm or 1.12/2.14 fpm.

It is worth mentioning at this point, that in designing the mill top there were several pertinent questions. First of all, was it possible to control the fine adjustment necessary for plate finishing on such large pitch screws? Secondly, what would the top of the mill look like with all this drive gear? Happily, on both counts the mill has been entirely successful.

In addition to the hydraulic spindle balance on the mill it was necessary to design a dual hydraulic roll balance system, one for the 2-high rolling and one for the 4-high rolling, and this was done by having two loaded accumulators, cross-connected so that one or other can be used by merely manipulating a few valves.

The physical dimensions of each mill housing are as follows:

Over-all height	44 ft-0 in.
Over-all width	16 ft-6 in.
Maximum thickness	8 ft-0 in.
Window dimension	22 ft x 56 in.
Weight of housing	308,000 lb.

The housing centers are 12 ft-10 in. and with a 4-high train in the stand the whole weighs in excess of 1,300,000 lb.

ROLL CHANGING MECHANISM

The emphasis from the beginning was on the fastest roll change possible and an elapsed time from steel to steel rolling of 30 min set as the target, and every effort in design was directed toward this end. At the start of operations a complete time study was made of roll changing and a standard procedure evolved, and after only a few months of operations roll changes were being made in 20 to 25 min.

With experience, further reductions can be made.

The roll changing mechanism is a dual arrangement of very heavy construction to support the weights involved. There is a traversing platform in front of the mill stand, with two sleds, to carry a 2-high and 4-high set of rolls. By traversing the platform either set of rolls is brought in line with the mill stand, and is motivated in or out of the stand by a rack and pinion drive. The sleds carrying the rolls move on lubricated skids. The fabricated steel floor covering the roll changing equipment, moves back and forth with roll movement, leaving a minimum opening at the mill floor level during a roll change. The opening left by the rolls that have gone in the mill has a special section of floor plate quickly replaced by a crane. The chockkeeper plates on the fixed side of the mill are pulled out of the way by cylinders on angular slotted holes, and oil, grease and water connections designed for fastest disengaging and closing.

The roll water headers are carried on the chocks with quick disconnects, the headers coming out with the chocks. The hydraulic descaling head on the down side of the mill can be hoisted by cylinder, up into the housing for minimum interference with the 2-high rolls.

To date ingots from 26 by 30 in. up to 29 by 36 in. have been rolled into blooms for a standard structural mill and slabs for a narrow hot strip mill. Larger ingots up to 31 by 62 in. have been rolled into heavy slabs up to 58 by 10¼ in. for rerolling into plate. The range of plate produced to date is from ¼ to 3 in. thick by 30 to 102 in. wide, and light plate, sidetrimmed to a finished width of 108 in. has been rolled experimentally.

The mill is so designed that the 4-high work rolls and the shear can both open to roll and shear slabs 16 in. thick.

SCALE DISPOSAL

A mechanical scraper scale disposal system operates under the mill as two individual units, deposits scale into a skip hoist which transports it directly to a car outside the building.

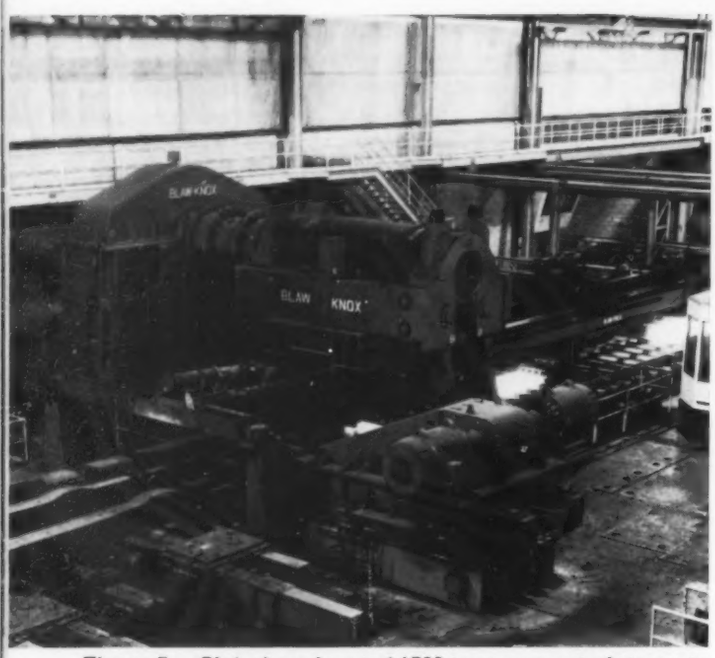


Figure 5 — Slab shear is rated 1500 tons, can cut plate up to 110 in. wide and heavy slabs.

One scraper operates from under the ingot buggy dump to a point up to the edger and the other from the shear under the mill, both interlocked so that they dump into the same skip hoist. Each unit has its own electrically driven winch, having a suitable drum for the scraper endless cables. A timing device is in the circuit so that scraping can be set to suit the amount of scale coming from the mill. Both scrapers are stopped by interlock when the transfer skip hoist is dumping in the scale car. On the mill stand unit the scraper track is so graded that mill water runs toward the shear, over a weir and into an automatic pump sump from which it is pumped to the sewer.

SCARFER

Between the mill runout and the shear approach table provision has been made to install at some future date a large bloom and slab scarfing machine. The necessary foundations and pull out table were provided during construction.

HOT SAW

A 72-in. diam sliding frame hot saw is provided just ahead of the shear to cut beam blanks for a 30-in. standard structural mill and a 50-in. universal beam mill or tube rounds from 7 to 10-in. diam. The side guards on the shear approach table are so arranged that they can be declutched from normal operating position, to a line where they will guide bars into the saw on one side of the table. This was necessary to keep the blade away from the crop pusher mechanism on the shear.

1500-TON SLAB SHEAR

Figure 5 shows a mechanical down-cut shear and as it was designed to cut plate up to 110 in. wide as well as heavy slabs, may be the largest and heaviest of its type ever built. The eccentric shaft operating the cutting head is 36 in. diam.

The shear is driven by two 375-hp, d-c motors directly-coupled through gears and is capable of cutting 650 sq in. at 1800 F. The knife length is 116 in. and the eccentric shaft stroke gives a maximum opening between knife faces of $18\frac{1}{2}$ in. The bottom knife is cooled by continuous water jets coming through the knife holding block. The shear has a holddown and back end butt push off. Slabs up to 60 in. wide by $10\frac{3}{4}$ in. thick, blooms and plate down to $\frac{1}{4}$ in. thick x 110 in. wide will be cut at this point. Contrary to earlier understanding, both large slabs and thin plate can be cleanly cut for a considerable time on the same knives. Immediately behind the shear is a pull back depressing table.

CROP DISPOSAL

The crop disposal hoist away from the shear is a cable-operated skip hoist of very heavy construction. The skip on four wheels is pulled out from under the shear and dumps into a car outside the main bay of the mill. A suitable hopper under the shear with automatic skip opened door takes care of butts or crop ends while the car is dumping.

SHEAR GAGE

A heavy overhung screw type gage is provided, operated from the shear pulpit and is suitable for gaging slabs up to 30 ft-0 in. long.

BLOOM PUSHER

A bloom pusher and transfer crane follows the shear gage and is on a center line with the existing skid transfer from the 44-in. blooming mill to the 30-in. structural mill. Blooms can therefore be transferred by these transfers from the 46-in. mill to the 30-in. structural mill, a distance of 492 ft-0 in.

SLAB PUSHER AND MAGAZINE PILER

Immediately behind the bloom pusher and going in the opposite direction into the 46-in. mill slab yard is located a slab pusher and magazine piler, which deposits piled slabs to a transfer car for transfer to the slab yard where they are unloaded by an overhead crane using "C" hooks. This pusher has a stroke of 18 ft-10 in. and a speed of 78.5 fpm and can handle slabs up to 30 ft-0 in. long x 60 in. wide and 8 in. thick. The drive is 75 hp at 515 rpm. The piler has a lift of 30 in. and a lift speed of 4 fpm.

HOT PLATE LEVELER

Immediately following the slab pusher is a hot plate leveler capable of leveling plate up to $\frac{3}{4}$ in. thick x 110 in. wide at a temperature of 700 F. It is a backed up type of leveler having work rolls of $9\frac{1}{16}$ in. diam and backup rolls of $9\frac{29}{64}$ in. diam maximum. There are nine work rolls and 18 backups, 23 in. long and the length of work roll face is 127 in. The rolls are water-cooled and a fan is provided to blow scale off the plate with nozzles directed parallel with the rolls. While the opening and closing of the rolls are motor driven and can be opened to 7 in. from face to face, the whole unit can be pulled out of the line, and has a replacement table attached. The main drive is a variable speed motor of 150 hp giving a leveling speed of 65 to 131 fpm.

FINISHING END TABLES

From this point on all finishing mill tables are individually driven and in some cases alternately driven, with the drive motors ranging from one to two hp. The spool table rollers are driven through hypoid gears, and the plate shearing line rollers are driven by "motor rollers" through composite planetary gears.

PLATE COOLING BED

The cooling bed, Figure 6, is 85 ft-4 in. wide and accommodates plates up to 80 ft in length and the distance from center line of run-in table to runout table is 65 ft-1⅞ in. The bed when full can hold five plates 80 ft-0 in. long by maximum mill width on the free space between tables, there is a rope transfer to take the plates off the leveler runout table and a chain transfer with spaced dogs to distribute the plates across the length of the bed. The bed has a steel supporting structure and on the skid surface cast iron grids.

SPOOL TABLE

Immediately behind the cooling bed runout table is a spool type table extending 588 ft-0 in. in a 22 ft-0 in. leanto bay, south of the main mill bay. The table has a frame of fabricated steel, has alternate individual drives, the drive consisting of a 1-hp motor at 1750 rpm driving through a small hypoid gear box. There are 148 driven and 147 idle rolls on this table having a body length over spools of 7 ft-5 in. The table speed is 277 fpm. It is the intention to keep this table full of plate, so that it too serves as a cooling bed. Inspection and marking is carried out on this table as the plates proceed into the finishing end. Heavy plate is taken off by a magnet crane onto a flame cutting line while light plate up to ¾ in. thick is taken off some 80 ft-0 in. from the end by a special crane for transfer to the plate finishing line or intermediate storage points.

PLATE TRANSFER CRANE

A low level transfer crane elevated so that the main mill cranes can pass overhead transports plate for shearing to the finishing line and has six box magnets on a spreader beam, capable of handling plates up to 80 ft-0 in. long. The crane is remote controlled by the same operator controlling the spool table and by preselecting the crane will pick up a plate and transport it to the finishing line or intermediate points.

PLATE FINISHING LINE

The plate finishing line consists of a number of tables all individually driven, a plate alining device, an edge-trimming shear, a dividing shear, a cross-cut shear and gage and a runout table with a plate weighing section. Scrap from both the trimming and cross cut shear is chopped into short lengths by auxiliary shears and transported by plate conveyors directly to a scrap car outside the building.

PLATE ALINING DEVICE

There are traversing magnets located between and below roll level on the trimming shear approach table. When energized they lift slightly to the plate and are transverse manipulated so that with a magnet on each end of the plate it can be squared easily and very quickly in direct view of the operator. Two fine parallel wires stretch from the trimming heads along the approach table and it is to these that the operator sets the plate. When the plate is properly alined to the trimmer, a carriage magnet running clear of the rolls to one side of the table, then pulls the plate forward into the trimming shear, the bottom alining magnets, of course, having been released. The drag magnet carriage is cable operated.

Figure 6 — Cooling bed can accommodate plate up to 80 ft long.

ROTARY TRIMMING SHEAR

The rotary trimming shear has one fixed and one movable head. The moving head runs on a spline drive shaft. It has a cutting speed of 78.7 to 179 fpm and a maximum finished trimmed width of 118 in. to a minimum closed width of 31½ in. and is designed for a maximum thickness of $^{25}/_{32}$ in. The circular knives are driven on each head by a 100 hp, d-c adjustable voltage motor at 985/1110 rpm. A rotary scrap chopper with two revolving heads is applied on both heads of the trimmer and edge trimmed scrap is fed through guides to the chopper where it is cut into short lengths which drop onto the scrap conveyor. Vertical and horizontal settings of the rotary trimming knives are motor operated through gears depending on the thickness of plate being processed. These motors are 3.5 hp at 1800 rpm, Figure 7.

ROTARY DIVIDING SHEAR

The rotary dividing shear is located immediately behind the trimming shear and is operated as required with the trimming shear, so that a plate can be trimmed to 100 in. wide and slit in 40 and 60 in. at the same time. The speed is again 78.7 to 179 fpm. The drive is 100 hp, d-c adjustable voltage at a speed of 985/1110 rpm. The housing adjustment drive is 34 hp at 720 rpm and gap adjustment for thickness drive is 3.5 hp at 1800 rpm.

Figure 7 — The rotary trimming shear has a cutting speed of 78.7 to 179 fpm.

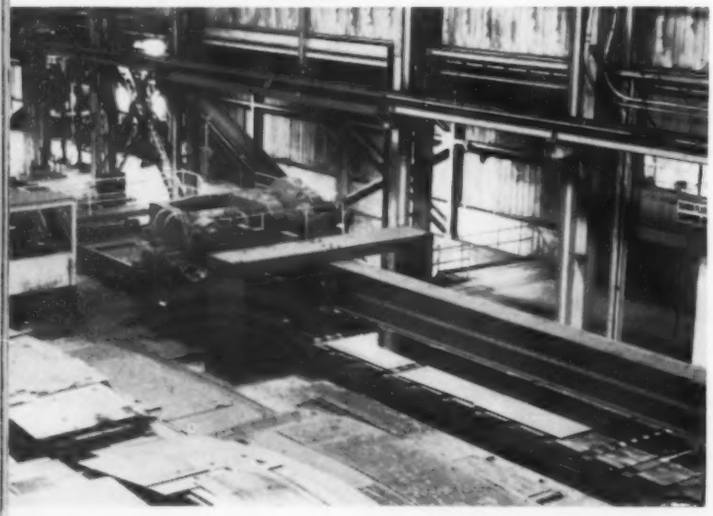
CROSS-CUT DOWN-CUT SHEAR

This start and stop type clutchless shear, Figure 8, will cut plate up to 1 in. thick x 118 in. wide and has a gage with a maximum measuring length of 650 in. It has a mechanical shifting device just ahead of the shear and a mechanical back end crop pusher. Crop ends drop onto a plate conveyor which has a small scrap shear which cuts the crops into short lengths, drops them on to another conveyor at right angles which in turn discharges scrap into the same scrap car that services the rotary trimming shear. The main drive is 186 hp, a-c at 720 rpm through gears giving the shear a maximum of 18 strokes per minute. The holddown drive is 45 hp at 720 rpm, a depressing table 19 ft-0 in. long follows the shear and has 19 individually driven rolls with 2-hp motors. The shear delivery table is 46 ft-0 in. long followed by a scale table 49 ft-2½ in. long where finished plates are weighed for shipment.

SERVICES

The finishing mill floor area is hot water radiant heated.

Figure 8 — The plate crosscut shear will cut plate up to 1 in. thick and 118 in. wide.



CRANES

There are eleven a-c cranes servicing the mill ranging from 10 to the 75-ton capacity, including the slab yard and finishing end semi-gantries. The slab yard overhead cranes have revolving trolleys for "C"-hook cross piling. For magnet operation the plate finishing crane magnets have a motor-generator d-c supply and the slab yard has a rectifier unit.

WATER

The mill water supply is circulated from the basic oxygen steel plant, some of which is pumped directly back into the plant mains ahead of the mill.

ROLL SHOP

The roll shop is a continuation and of similar construction to the main motor room, divided however, by the slab transfer car track from the mill to the slab yard. A large grinder with a cutting attachment has to date taken care of the 4-high rolls, while the 46-in. 2-high rolls have been dressed in the existing 44-in. mill roll shop.

STARTUP AND OPERATION

by J. H. WALSHAW

Superintendent, 46-In. Blooming and Plate Mill

Algoma Steel Corp., Ltd.

Sault Ste. Marie,

Ontario, Canada

NO labor or staff below assistant superintendent level with experience of the operation of a wide plate mill were available at the Algoma Steel Corp., Ltd.

We were not unduly depressed about this as plenty of experienced steel mill men were available and it was felt that, with training, they would make excellent plate mill crews. The value of giving key men experience of the operation of plants similar to those which they were to man had been amply proved in the recent excellent start of the basic oxygen steel plant. We were extremely fortunate in being able to obtain similar facilities for a group of key men for the plate mill.

It was decided to start the mill up on one-turn operation with provision for fairly rapid expansion to two turns when the men obtained more experience and the almost inevitable "teething troubles" were ironed out. Following this, customer demands permitting, there was to be further expansion to three-turn operation as quickly as possible on the basis of five turns per week of slab and bloom production and ten turns of plate production.

There are jobs in any mill which require more training and experience than others and to speed up the expansion of production it was decided to train two crews of key men from the start. The crews required to operate the mill were carefully worked out, each job was evaluated according to the assigned duties and temporary rates of pay fixed. Preliminary lines of sequence were evolved so that men were promoted to more senior jobs in their own particular sphere of opera-

tions as production was expanded. All but the staff jobs were posted. Approximately 200 men were interviewed and 55 chosen for the initial crews.

Four turn general foremen, two finishing and shipping foremen, two rollers and two manipulator operators were selected some weeks before the mill was due to start. The rollers and manipulator operators all had experience of rolling in a 44-in. blooming mill which is the other of Algoma's primary mills. The two rollers and two manipulator operators spent four weeks observing other plate mill operations. The foremen together with two production planning staff also spent one week at a plate mill while the assistant superintendent of the mill and one of the finishing foremen flew to England and were at a plate mill for one week studying a rotary shearing line which is very similar to that installed at Algoma. The remainder of the crews were engaged three weeks prior to the mill starting. During this period they were given talks in connection with bloom and plate production and were able to study the mill in general and their own area in particular. Some plate was obtained for trials on the shear line and the operators were able to get some operating experience before the mill started up.

The mill started production on Monday, February 23, 1959. For some time prior to this the mill crews familiarized themselves with the controls. Ingots only were rolled during the first week and the previous experience of the mill crew in this operation was very helpful. During this first week we overcame many of the inevitable teething troubles and the operators gradually become more familiar with the equipment.

The first slab was successfully rolled into a plate ½ in. thick on March 3rd. There was a fair share of trouble during this first week of plate rolling, the main ones being the removal of primary or furnace scale and the operators getting used to strange controls.

Both ingots and plates were rolled during the third week and in the week following the second crew was started and operated ten turns per week. Plates were rolled during the day shift and the increase in operations went smoothly due to the extra men trained for key positions. At this stage extra men were engaged for training and on April 26, fifteen-turn operations commenced. Rapid promotion through some of the lines of sequence set us back a bit but recovery was fairly rapid. We are now working a 20-turn week with four trained crews and trained reserves.

To assist in maintaining efficient operation of the soaking pits, which serve both the 44-in. blooming mill and the bloom and plate mill, ingots are rolled for two four-hour periods and plates for two eight-hour periods on most days. The exception is when an ingot rolling turn is substituted for a plate turn on the day when the other blooming mill has its repair turn.

Ingot rollings increased progressively on a mixed product of large slabs for plate and sale, smaller slabs for the bar and strip mill and a small tonnage for the rail and structural mill. Approximate rolling rates are now up to 300 tons per hour on the larger ingots and products and up to 150 tons per hour on the smaller sizes.

We are rolling an average of 360 tons of plate per turn with an increased percentage of light gage plates and in spite of the intermittent nature of the present rolling schedule.

Trouble was experienced with score marks on the liners of the chocks and mill housings. Harder liners have now been fitted to the housings and the steel liners on the 2-high chocks have been replaced with bronze.

Due to the nature of the combination mill, the distance between the centers of the rolls and the first feed rollers is 53 in. In the 4-high setup, part of the resultant gap is covered by the bottom roll stripper guides. This gap restricts us to a minimum slab width for cross rolling of 43 in. and a minimum ingot length of approximately 56 in.—narrower slabs tend to stick on the guides and shorter ingots tilt and stick in the gap. This gap also allowed slabs and plates which turned down to strike the first feed roller at a low level. Heavy glance guides have now been fitted to guide such slabs and plates to the upper part of the rollers thus reducing the possibility of damage. They also prevent the formation of sharp downward bends on the leading end of any plate which turns down and reduces the risk of them finding their way down between the rollers of the feed tables.

INGOT ROLLING

Ingot rolling gave very little trouble because of the previous experience of the operators. Speed control of the mill was difficult as there was no positive "feel" for the six speed points on the foot controller. The rollers were hesitant in its operation as they did not want to use full speed at first. This problem was overcome by limiting the travel of the foot pedals to give base speed only and a speed selector switch has now been installed which enables the roller to choose a maximum speed to suit prevailing condition. The rolls have a bull head 67¾ in. wide and three edging passes: 15, 9½ and 5 in. wide. Slabs over 30 in. wide receive the last edging pass in the 15-in. hole, all subsequent edging being done in the vertical edging stand which has given excellent results. The automatic screwdown was brought into use in November and is being used for all standard sizes of slab products.

PLATE ROLLING

As scale removal is a problem in most plate mills it is not surprising that there was some difficulty in this respect. It was complicated during the starting up period by the fact that plates were rolled on one turn only each day which involved shutting the reheating furnace down after each rolling. Scale on the slabs left in the furnace overnight was heavy and although a pass through the edging rolls cracked it up it was difficult to remove with the descaling jets because of its weight. The turn up gear on the side guards proved very useful under these conditions as the slabs could be tilted to allow the scale to fall off. The slabs heated after the initial charge had a lighter scale which the edging rolls loosened only at the slab edges and the descaling jets were not powerful enough to loosen and remove the remainder. Although the scale remaining on the slab was nearly always removed after a few passes through the mill, some pitted plates resulted.

From the start, of course, the effect of correct furnace conditions was appreciated. In the early stages furnace control was complicated by the fact that low outputs in

the mill resulted in the high capacity furnace being operated at a small fraction of its designed heating rate. The volume of gas and air required was small in relation to the designed consumption which affected flame intensity and direction and also the maintenance of correct furnace pressures.

A close study of furnace conditions permitted development of a method of heating which produced a scale which could be removed relatively easily. Furnace zone temperatures are adjusted to produce a slight decrease in slab surface temperature as the slabs are soaked prior to delivery of the mill. This procedure results in a scale which becomes detached from the surface of the steel but great care has to be exercised to maintain the conditions when changes of slab thickness occur in the charge. There is now little trouble with scale removal in spite of our present rolling schedule.

Acting on the experience of another mill, it was decided to commence rolling with no camber in either the work or back up rolls. Fairly good results were obtained on wide heavy plates up to about 40 ft long, but there was trouble with plates cambering on the narrower, thinner and longer ranges. We now mount work rolls which are ground 0.008 in. less in diameter at the center than the ends but still maintain parallel backup rolls. This arrangement has given reasonable results.

The rollers very soon found the variation in the spring of the mill under varying plate width, thickness and temperature conditions.

Thickness reduction per pass was cautious at first and was increased as experience was gained. Present practice is to use a 30 per cent reduction per pass on the widest plates with a maximum of $\frac{3}{4}$ in. during the greater part of the rolling and to reduce to quite light drafts for finishing the plate to the correct gage. Somewhat heavier reductions are used on narrow plates.

The roller is supplied with a printed form for each individual slab sent to the mill. It details all dimensions of the slab provided and the rolled plate to be made as well as the theoretical thickness reduction necessary to obtain the required plate width. The calculated thickness does not always produce exactly the width required and the roller has to use his judgment to correct variations.

For the first seven months of operation all width measurement of the plates had to be made with the sideguards which are equipped with a selsyn operated indicator for this purpose. This involves turning the slab through 90 degrees after rolling down to the calculated thickness required. If the width is too narrow the slab must be turned again, further reduced and turned yet again for final rolling down to the finished gage.

Turning slabs on the tapered rollers of the main mill table was very troublesome at first. This operation is fairly simple with a perfectly flat slab but even experienced operators have difficulty with slabs which have turned up or down on delivery from the mill. Some benefit was obtained by limiting the rollers to the slowest speed when they were being counter rotated. The men are now very much more experienced and also find that they can use the heavy sideguards for turning the more awkward slabs.

Care has to be taken when using the sideguards for centering plate on the mill tables. They are very powerful and can easily crush and distort a plate. This did happen occasionally during the startup period.

Estimation of the allowance necessary to cover width variation caused by shape distortion during the early stages of rolling caused some difficulty at first. This resulted in some plates being finished too narrow or too wide.

A widthmeter to measure the width of the plates before turning and completion of rolling has recently been installed. It is set to the required width by pushbutton control in the rollers pulpit and indicates to the roller the deviation from this width when the plate is correctly positioned. The slow movement of heads when changing from one width to another limits its usefulness at present and an automatic control of the heads to a preset dimension is presently being sought. For this reason the width of most plates are still measured by the sideguards.

A gamma-ray gage was installed in November, 1959, and is presently undergoing trials.

Initially, rolled plate sizes were restricted to give a maximum finished width of 96 in., a maximum length of 40 ft and a minimum thickness of $\frac{3}{8}$ in. As the crews gained experience, progressively lighter gages were rolled until the nominal minimum of $\frac{1}{4}$ in. plate was reached. Rolled lengths and widths were then gradually increased. Examples of finished plate sizes presently being produced are:

96 x $\frac{1}{4}$ in. x 60 ft-0 in.
106 x $\frac{5}{16}$ in. x 40 ft-0 in.
106 x $\frac{3}{8}$ in. x 40 ft-0 in.
96 x $\frac{3}{8}$ in. x 80 ft-0 in.
60 x $\frac{1}{2}$ in. x 80 ft-0 in.
100 x $\frac{5}{8}$ in. x 60 ft-0 in.

Recently, successful trials of plate rolling using the automatic screwdown gear have been made and it is the intention to use this method of rolling when quantities of any particular size warrant it. The edging stand is being used for controlling the side scrap on the thicker plates and is providing useful experience for the eventual production of plates with a rolled edge as well as increasing mill yields.

ROLL CHANGING

The roll changing rig was designed to achieve a change over from bloom and slab rolling to plate rolling in 30 min but we hope to eventually change rolls from one set to the other in 15 to 20 min. We have achieved a 20-min change once to date with several near misses.

From the start, it was planned that roll changing would be carried out by the mill crew with as little help as possible from assigned maintenance squads. Due to certain problems that arose the assistance of the millwrights is required but alterations carried out have largely eliminated their duties and it is expected that they will eventually be able to utilize most, if not all, of the downtime on maintenance. A certain amount of pipe fitting may always be necessary but while this is being done, essential checking of oil and grease systems is being carried out.

Soon after the mill started operating it became very evident that some alterations and additional equipment were required to reduce roll changing time. Some roll

changes were delayed by accumulations of scrap—this had to be removed before the 2-high set could be withdrawn. Glance plates have been fitted to make any scrap fall clear of the base of the mill. The blocks around the center pins of the universal couplings on the spindles were originally made of steel and were fitted with bronze wearing plates attached by countersunk bolts. During roll changing, unless the rolls and spindles were lined up extremely accurately, the wearing plates were sheared off as the ends of the roll driving boxes entered the spindle ends. These blocks have now been replaced by ones made of solid bronze with a radius on the outer end which are almost self alining. Smaller valves have been fitted to the hydraulic roll and spindle balance system to provide better control of movement when setting the rolls for changing. Pointers have also been fitted to assist in lining up the spindles, roll balance beam and rolls to standard set positions for correct alinement prior to removing or entering the sets of rolls. We are presently considering alterations in the pipe work for grease and water supplies to reduce the time required for coupling and uncoupling. A motion study has been made of the roll changing and a standard procedure setup. The men involved in roll changing are enthusiastic about speeding up this operation and have brought forward many useful ideas.

Rolls are usually changed after rolling the following tonnages:

2 High.....75,000 tons ingots.
4-High work rolls..2000 to 2500 tons finished plate.
4-High backup rolls.35,000 tons finished plate.
Edging rolls.....250,000 tons ingots.

Hot shear blades are changed after 14 days operation.

The trials made on the shearing line before the mill started rolling enabled the operators to get a little experience before having to deal with the plates from the mill. A few minor troubles were put right during this period and the line has worked very well since. As outputs increased, the semi-gantry crane proved to be too slow in removing the shorter plates. Orders for short lengths have proved to be greater than originally anticipated when the mill was designed and delays to the shearing line occur. We are presently planning to install a plate piling device. Rotary shear blades are changed on the average after shearing 1700 tons and the scrap cutting knives after shearing 3000 tons. The cross cut shear blades are changed when required—usually after shearing 6000 tons.

As was to be expected, rolling errors made during the training period affected the rapid completion and shipment of orders. Due to promotions as operations were expanded, the original loading crews were severely depleted and this caused some temporary difficulty in getting steel shipped.

PROVIDING

The procedure used is fairly standard. Plates ordered by customers are grouped together to form a convenient size for rolling and shearing, due consideration being given to the qualities and physical properties required. Side and end scrap allowances are then added and the weight of the rolled plate calculated. An additional percentage of this weight is then added to allow for scarfing and reheating losses and variations in gage caused by roll wear, etc. The resultant figure is the slab weight to be provided. The mill provider then assesses the most suitable slab size for this weight using weight tables and his knowledge of plate rolling procedure. The allowances are listed in a table and are based on the practice of another plant. They were increased somewhat to allow for the inexperience of the rolling and shearing crews. These extra allowances have been progressively cut as initial difficulties were overcome and the extra crews required for increased operation became more proficient.

The training of a providing staff from scratch was no mean task but the men concerned were keen and enthusiastic and soon settled down to the methods used. The biggest problem was the development of speed in providing and there were times when it was difficult to keep up with the mill—this was aggravated by the fact that the printing machine was not available for some time and all the form sets had to be made out by hand.

MILL SYSTEM PROCESS CONTROL

A process control system was developed some time before the mill started. It is built up around the provision of a five-part form set for each slab rolled. This form set has two main parts, the upper part which details all the essential information about the finished plate to be cut and the lower part with details of the rolled plate and the slab provided to make it. The plate portion may consist of one or more sections according to the number of different items built up into the rolled plate.

These form sets are made out by the providing staff. If more than one form set is required for any particular build up of plate, they are reproduced on a printing machine from a master copy. The slabs required for the rolled plates are then suitably grouped together to form the product of an ingot and a requisition is made out for each ingot required. This gives full details of the ingot size required, specification, method of manufacture as well as the slab sizes to be rolled and cut.

When ingots are made, charged and ready for rolling, a copy of the ingot requisition, together with the form sets for the slabs to be cut, is sent to the cutter at the slab shears. As the slabs are cut, the necessary additional information is entered on the form sets and these are sent to the slab yard at the same time as the slabs are delivered. From this stage the form set follows the slab through all stages from scarfing to finished sheared plate. Parts of it are removed to supply rolling and other details to the operators in the mill and other parts form the basis of production and progress reports as the plate is processed. Once the plates have been sheared, the bottom copies of the form sets are used as inventory record cards and finally as a record of the plates loaded.

There is still some way to go before we meet the output standards of well established mills but we are producing high grade plates with an excellent finish which are metallurgically sound and free from scratches. We have made a reasonably good start, and a profitable operation has been established.

Credit for such progress must be divided between those involved in the design and construction of the mill, friends in the steel industry and the staff and men who are enthusiastic about their new department and are working hard to make it a success. ▲

The President's Message

As we in the steel industry face the year ahead, we find on one hand the challenge of intense domestic and foreign competition. On the other hand, the uncharted era of the nuclear and space age offers us a completely new horizon.

The steel industry has shown a wide acceptance and aggressive utilization of new techniques associated with all phases of steelmaking. Organizations such as the Association of Iron & Steel Engineers, through the medium of technical sessions and research projects, are essential to the growth and development of these changes. This indicates the need for a broadened research program for the ensuing year.

We can also be of service to the younger members of our organization by providing programs geared to their needs. Our technical articles have proven to be an asset in the development of the individual's job knowledge and will continue to be a most important part of his working reference library.

It is with optimism we accept the challenge of the future. We can and must carry on our heritage of service for the steel industry.

C. E. PRITCHARD
President, AISE

C. E. Pritchard

President, 1961

Association of Iron and Steel Engineers

C. E. PRITCHARD was born in Pittsburgh, Pa., and was graduated from Carnegie Institute of Technology in 1932. He first worked for the Atlantic Refining Co. where he stayed until 1937, at which time he entered the steel industry. He then became employed in mill maintenance at the Warren district of Republic Steel Corp., with a later appointment as district lubrication engineer. In 1941 he was promoted to chief lubrication engineer of all Republic Steel's operations with headquarters in the general office in Cleveland. In 1951 he joined the Alan Wood Steel Co., serving as superintendent of finishing mills. The following year he was promoted to superintendent of mills, including all rolling mills and finishing operations. In 1957 he was appointed to the position of general superintendent of mills, the position he now holds.

AISE Officers and Directors, 1961

H. L. JENTER
First Vice President

HARRY L. JENTER was born in Trenton, N. J., in 1901. He joined the American Steel & Wire Division's Trenton works in 1917 as a draftsman, and for the next few years alternately worked for the division and attended college. In 1926 he was graduated from Syracuse University with a degree in mechanical engineering and transferred to the Cleveland office. In 1928 he was made assistant foreman at the Newburgh Wire Works. Mr. Jenter was transferred to the Cuyahoga works cold roll strip department in 1932, and in 1934 was made general foreman. He became assistant superintendent of the works in 1935, general superintendent in 1939 and in 1942 transferred to the headquarters office as assistant to the vice president of operations. He resumed the post of general superintendent of Cuyahoga works a year later, was made chief engineer in 1950, assistant district manager in 1952 and manager of operations—Cleveland District, American Steel & Wire Division, United States Steel Corp., in 1953. In 1956, he became vice president of operations.

C. W. BRUCE
Second Vice President

C. W. BRUCE was graduated from Case Institute of Technology in mechanical engineering in 1933. He started in the steel business in the blooming mill at the Corrigan-McKinney Steel Co., and in 1934 transferred to the combustion department. After the merger with Republic Steel Corp. in 1935, he continued in the combustion department until 1942, at which time he was transferred to the Chicago district as combustion engineer. In 1947 he was made assistant chief engineer of the Chicago district and in 1951 chief engineer. In January, 1958, he was transferred to the general office as chief engineer of steel plants for Republic Steel Corp.

H. R. KNUST
Treasurer

H. RUSSELL KNUST was born in Jessup, Md., in 1918. He was graduated from the University of Maryland with a Bachelor of Science degree in mechanical engineering in June, 1940, when he entered the "Loop" course of the Bethlehem Steel Co. In August, 1940, he was transferred to the Sparrows Point plant, mechanical department. At this plant he progressed from field foreman to assistant master mechanic of mills, to supervisor of maintenance, to assistant superintendent of mechanical department, superintendent of mechanical department, to assistant to general manager and in 1956 he was appointed assistant general manager, the position he now holds. He is a member of the AISI, ASME and past president of the Engineers Club of Sparrows Point.

N. C. MICHELS
Secretary

N. C. MICHELS was graduated from Purdue University with a degree in electrical engineering in 1936 and later did graduate work at Loyola University and M.I.T. He entered the employ of United States Steel Corp. in Pittsburgh in 1941 in the engineering department. He left the service of United States Steel in 1947, returning to its engineering department in 1950. He was transferred to the Tennessee Coal & Iron Division of United States Steel in December, 1954, and was elected vice president—engineering of that division on September 1, 1955. On January 1, 1961, Mr. Michels was appointed vice president, facility planning and appropriations, United States Steel Corp., Pittsburgh, Pa.

H. A. LONG
Director-at-Large

HERBERT A. LONG is a native of Pennsylvania and attended public schools in that state. He attended Waynesburg College and studied engineering while working for the Pittsburgh Steel Co. During his period of employment with Pittsburgh Steel, he served as inspector, then transferred to engineering and held positions as blue print clerk, draftsman, chief draftsman, and chief engineer. In 1957 he became general manager of operations, his present position.

M. B. ANTRIM
Director

M. B. ANTRIM, a native of Pennsylvania, received an electrical engineering degree from Rensselaer Polytechnic Institute in 1938. After a brief period with Repp & Menzies, consulting engineers, Scranton, Pa., he was employed by Westinghouse Electric Corp., East Pittsburgh, Pa., and upon completion of the technical training course was assigned to Philadelphia. He joined Lukens Steel Co. in 1941 as technical assistant to the electrical superintendent and since then progressed successively in the electrical department to electrical engineer, assistant superintendent, and then superintendent. In 1953 he was appointed assistant manager of the maintenance and construction division and in 1957 became project manager of the Lukens Steel Co.'s $33,000,000 expansion program. In 1959 upon completion of this program he was named to his present position of manager, engineering and construction division.

H. W. DORSET
Director

H. W. DORSET was graduated from Clemson College, South Carolina, receiving a bachelor of science degree in electrical engineering in 1930. He joined the Westinghouse Electric Corp. in Pittsburgh on the test course and was transferred to the Baltimore office in 1932. In 1933 he entered the employ of the Bethlehem Steel Co., Sparrows Point plant in the 110-in. plate mill, and in 1935 was transferred to the electrical department construction division. Mr. Dorset has served as construction foreman and assistant electrical engineer. In 1952 he became assistant superintendent electrical department, which position he now holds.

F. M. FARRAGHER
Director

FRED M. FARRAGHER was born in Youngstown, Ohio. In 1930 he joined the United States Steel Corp., starting in the boiler shop, then working in the various Youngstown district plants—the lower mills, upper mills and the McDonald plant, and transferring to the machine shop at McDonald. In 1948, Mr. Farragher became assistant general foreman of blast furnace maintenance, in 1951 he was made general foreman, and in 1952 was named superintendent. On January 1, 1958, he was promoted to his present position as superintendent blast furnace auxiliaries.

E. W. FITCH
Director

EDWARD W. FITCH was born in southern Indiana. He graduated from the University of Kentucky with a bachelor of science degree in mechanical engineering in 1924. After some years in instrument and combustion control engineering work, he joined Republic Steel Corp.'s Cleveland district in the combustion engineering department. In 1944 he was appointed chief combustion engineer for Republic's Youngstown district, which position he still holds.

J. H. FRANZ
Director

JAMES H. FRANZ was born in Glenshaw, Pa. After completing high school at Etna, he started work with Carnegie Steel Co. as an electrician's helper. From 1929 to 1941 he held various jobs in the maintenance and engineering departments. Meanwhile, he attended Carnegie Institute of Technology night school, receiving a bachelor of science degree in electrical engineering in 1941. He was made chief electrical engineer of Carnegie-Illinois Steel Corp. ordnance engineering bureau and in 1943 was transferred to the company's Youngstown district. In 1946 he was named assistant to the division superintendent of maintenance of the Youngstown district and in 1948 became superintendent of operating maintenance. He was then made superintendent of the fabricating shops at the McDonald mills. In 1951 he was transferred to U. S. Steel's Edgar Thomson works as superintendent of operating maintenance, his present position.

R. J. GARMY
Director

ROBERT J. GARMY, a native of Canton, Ohio, started in 1937 in the electrical maintenance and construction department of Republic Steel Corp.'s central alloy district, Canton, Ohio. Mr. Garmy served four and one-half years with the Navy during World War II. In 1947 he was appointed electrical engineer with the central district and in 1956 was made assistant chief engineer. In May, 1959, Mr. Garmy was temporarily assigned to the new hot strip mill project in Republic's Warren district.

H. V. GUMMA
Director

HAROLD V. GUMMA was born in Denver, Colo., and educated in the Denver school system. He attended the Colorado School of Mines receiving his degree in metallurgy in 1937. He joined the Colorado Fuel and Iron Corp. as metallurgical assistant shortly after college graduation. In 1940 he was transferred to the mechanical department as turn foreman at the shell forging plant, and in 1941 was named general foreman of this plant. After the shell plant was closed, Mr. Gumma was transferred to the industrial engineering dept., then entered the rolling mills as turn foreman. In 1947 he was promoted to general foreman, rolling mills, and in 1950 was appointed to assistant superintendent, rolling mills, which position he now holds.

R. D. HINDSON
Director

R. D. HINDSON was graduated from McMaster University with an Honour degree in chemistry and geology. He has since been associated with The Steel Co. of Canada for almost twenty years in various metallurgical capacities. At the present time he is assistant chief metallurgist of all works of The Steel Co. of Canada, Ltd.

R. W. HOLMAN
Director

R. W. HOLMAN is a native of Chicago, Ill. He was educated in public schools of Gary, Ind., and attended Purdue University, receiving a B.S. degree in electrical engineering. Mr. Holman joined United States Steel Corp's. Gary Sheet and Tin Mill, in 1929. He left there to continue his schooling and returned to the plant in 1935 as a laborer. He was promoted to power foreman within a few months. In 1946 he was advanced to electrical engineer, and in 1950 was promoted to assistant works chief engineer. In 1951 he was made works chief engineer, and by the end of 1952 was named assistant general superintendent of the works.

In 1954 he was appointed to assistant vice president—research and technology in Pittsburgh. After holding several responsible positions in research and technology, in 1958 he was named division chief engineer, Tennessee Coal & Iron Division, and on January 1, 1961, he was made director of engineering.

R. L. HUMPHREYS
Director

R. L. HUMPHREYS was born in Baltimore, Md. He graduated from Rensselaer Polytechnic Institute with a bachelor of mechanical engineering degree. During World War II, he served three years in the armed forces. In 1947 he entered the employ of Bethlehem Steel Co., Sparrows Point plant as an engineer (mechanical), first in the hot strip mills and later in the general mechanical department. In 1953 he was appointed to the position of lubrication engineer, and since 1958 he has served as assistant master mechanic, coke oven department.

J. R. HUNT
Director

JOHN R. HUNT was born in Cedartown, Ga., but early in childhood moved to Birmingham and attended Birmingham public schools. Mr. Hunt entered the employ of Tennessee Coal & Iron Div., United States Steel Corp. in 1926 as a messenger in the accounting dept., Ensley Steel Works. He attended Birmingham-Southern College, graduating in 1931 with a bachelor of science degree in chemistry. He later took postgraduate work at Birmingham-Southern and the Birmingham center of the University of Alabama. While attending college he held various positions in the Ensley and Fairfield plants. After graduation he was made supervisor of water treatment in the steam engineering dept. holding that position until 1936. He then was transferred to the Ensley blast furnace dept. as senior practice man, and advanced to assistant superintendent of blast furnaces in 1938. He was made superintendent of blast furnaces, Holt, Ala., during World War II, and returned to Ensley as assistant superintendent of blast furnaces in 1944. In 1948 he was made assistant to the manager of industrial relations, was transferred back to operations in 1949 as assistant to the general superintendent of the Fairfield Sheet and Tin Mills. He was promoted to superintendent of the Fairfield Sheet Mill, and in 1951 was promoted to the assistant general superintendent of the sheet and tin mills. In 1954 he became general superintendent of the Fairfield Tin Mill and later advanced to his present position as chairman of operating committees, TC&I Division.

B. W. HYDE
Director

B. W. HYDE was born in Hannibal, Mo., in 1912. He was educated in the public schools in that city and was graduated from the University of Missouri in 1933, receiving a bachelor of science degree in engineering. For eight years he was employed in highway and building construction. He spent three and one-half years in the Corps of Engineers during World War II with two years in the CBI theatre on the Ledo and Burma roads where he attained the rank of Major. In 1946 he joined the Laclede Steel Co. as a construction engineer, and was made superintendent of service and maintenance in 1955 which position he still holds.

G. S. KOSS
Director

GEORGE S. KOSS is a native of Gary, Ind., and attended school in that city. In 1935 he joined the Gary Works, United States Steel Corp., as a laborer. In 1938 he was transferred to the Irvin Works, holding various positions in the sheet and tin mill. In 1948 he returned to Gary as general foreman, cold-reduction mill. In 1950, Mr Koss was named superintendent of the cold reduction mill at the Pittsburg, Calif., works, and in 1952 was made superintendent—slab, plate and strip mills at the Geneva Works. In August, 1956, he was promoted to his present position as assistant division superintendent rolling mills, Geneva Works.

E. O. KRUEGER
Director

ELMER O. KRUEGER, a native of Illinois, attended public schools in Illinois and Florida. In 1925 he started working for Acme Steel Co., Chicago, Ill., as an electrician's helper, advancing to a motor inspector and hot mill motor room operator. In 1942 he became the electrical maintenance night turn foreman, in 1946 was made foreman electrical construction and repairs, and in 1956 was made general foreman. He is now general foreman, utilities.

G. M. KYLE
Director

G. M. KYLE was born in Liverpool, England, and attended public schools at Princeton, West Virginia. He served a machinist apprenticeship with the Virginian Railway from 1928 to 1932. He attended West Virginia University and received a B.S. degree in mechanical engineering in 1937. In 1937 he entered the steel industry, joining the American Steel and Wire Div., United States Steel Corp., serving in various capacities, and advanced to mechanical foreman of blast furnaces and power plant. In 1946 he joined Inland Steel Co., and worked as assistant general mechanical foreman in the open hearth department and then in the sheet and galvanizing department in the same capacity. In 1950 he became assistant superintendent, electrical department, and in 1951 was named assistant superintendent, mechanical department, in the flat products, primary production, and shape products groups, the position he now holds.

J. L. LAIDLAW
Director

J. L. LAIDLAW was born in Glasgow, Scotland, and received his education in Glasgow. He attended Royal Technical College, Glasgow, receiving a degree in mechanical engineering. He entered the steel industry at Bairds & Scottish Steel, working there from 1932 to 1938, and in 1938 he joined Colvilles Ltd. In 1947 he joined Algoma Steel Corp., Ltd., Sault Ste. Marie, Ontario, Canada, as assistant mechanical superintendent; in 1949 he became assistant to works manager, in 1950 was named superintendent of construction, and in 1952 he was promoted to division superintendent maintenance and services. In 1957, he was made manager of engineering and construction, his present position.

J. S. MOORE
Director

JACKSON S. MOORE attended the University of Utah in Salt Lake City, majoring in mechanical engineering. He moved to the Los Angeles area, joining the Columbia-Geneva Steel Div., United States Steel Corp., Torrance Works, in 1936, as third helper in the open hearth department. Subsequently he has held positions as industrial engineer, maintenance engineer, assistant superintendent of maintenance, superintendent of maintenance and utilities and assistant superintendent of rolling mills, the position he now holds.

R. C. SCHAEFER
Director

RICHARD C. SCHAEFER is a native of Canton, Ohio, and attended public schools there. He attended Mt. Union College from which he left to enter the United States Army in World War I. In 1918, returning from the service, he started at the Timken Roller Bearing Co., transferring in 1924 to their Steel and Tube Div. He worked in the tube mill, advancing to superintendent of finishing. He left Timken in 1933, joining Wheeling Steel Corp. at Steubenville, Ohio, in the flat products division, and worked his way up to his present position as assistant superintendent of rolling, in charge of hot strip mill, soaking pits and blooming mill.

W. L. MURPHY
Director

W. L. MURPHY attended the California Institute of Technology under the Naval V-12 College Training Program graduating in 1945 with a bachelor of science degree in mechanical engineering. In 1947 he received a master of science degree in production engineering from Stanford University. He entered the employ of the Bethlehem Steel Co. in 1947 as a member of the loop course training program. He was subsequently assigned to the South San Francisco plant, progressing through the following positions: draftsman fuel engineer, assistant superintendent open hearth department, and assistant to the general manager. In 1958 he was appointed to his present position of assistant general manager of the South San Francisco plant.

W. P. SMITH
Director

WILLIAM P. SMITH was born in Pittsburgh, Pa., and attended schools in that vicinity. He attended the University of Pittsburgh and graduated in 1941, receiving a bachelor of science degree in electrical engineering. He entered the employ of the General Electric Co. first, engaging in the design of locomotive and mill motors. In 1947 he was transferred to the steel mill application engineering group. In 1952 Mr. Smith joined the Jones & Laughlin Steel Corp., Aliquippa Works as electrical foreman in the tin mill. In 1953 he was made general foreman, maintenance, tin mill, and in 1955 was named general foreman, maintenance, south mills. Later in 1955 he was transferred to the Cleveland Works division as assistant works manager, which position he now holds.

1961 AISE National Committees

General Chairman, C. E. Pritchard

Advisory Committee

Past Presidents, AISE

1921 E. S. JEFFERIES, Largo, Fla.
1923 R. B. GERHARDT, Philadelphia, Pa.
1924 R. S. SHOEMAKER, Middletown, Ohio
1930 F. W. CRAMER, Pittsburgh, Pa.
1931 F. O. SCHNURE, Wallpack Center, N. J.
1932 J. J. BOOTH, Pittsburgh, Pa.
1935 W. H. BURR, Coatesville, Pa.
1937 H. G. R. BENNETT, Eustis, Fla.
1938 L. F. COFFIN, Easton, Md.
1940 J. A. CLAUSS, Walled Lake, Mich.
1941 W. A. PERRY, Milford, Ind.
1944 CHARLES L. McGRANAHAN, *Technical Assistant to Works Manager*, Sollac, Seremange (Moselle), France
1946 FREEMAN H. DYKE, Jupiter, Fla.
1949 C. H. WILLIAMS, *Administrative Vice President, Engineering*, United States Steel Corp., Pittsburgh, Pa.
1950 A. S. GLOSSBRENNER, *President*, Youngstown Sheet and Tube Co., Youngstown, Ohio
1951 *Chairman:* JOHN F. BLACK, Philadelphia, Pa.
1952 I. N. TULL, *Electrical Superintendent*, Republic Steel Corp., Cleveland, Ohio
1953 JOHN L. YOUNG, *Vice President Engineering Technology*, United States Steel Corp., Pittsburgh, Pa.
1954 E. L. ANDERSON, *Superintendent Electrical Dept.*, Bethlehem Steel Co., Johnstown, Pa.
1956 W. H. COLLISON, *Plant Superintendent*, Blast Furnaces & Coke Works, Great Lakes Steel Corp., Ecorse, Mich.
1957 J. D. O'ROARK, *Assistant Manager*, Dept. of Service & Maintenance, Electric, Weirton Steel Co., Div. of National Steel Corp., Weirton, W. Va.
1958 LEONARD LARSON, *Chief Engineer in Charge of Flat Rolled Products*, Cleveland, Ohio
1959 EMIL KERN, *Vice President—Engineering*, Allegheny Ludlum Steel Corp., Brackenridge, Pa.
1960 S. C. READ, Pittsburgh, Pa.

Membership Committee

Chairman: C. W. BRUCE, *Chief Engineer, Steel Plants*, Republic Steel Corp., Cleveland, Ohio
M. B. ANTRIM, *Manager, Engineering & Construction*, Lukens Steel Co., Coatesville, Pa.
W. P. SMITH, *Assistant Works Manager*, Jones & Laughlin Steel Corp., Cleveland, Ohio
C. J. McELHANY, *Superintendent Open Hearth*, Columbia-Geneva Div., United States Steel Corp., Pittsburg, Calif.
F. L. BULLARD, JR., *Supervisor of Training*, Tennessee Coal & Iron Div., United States Steel Corp., Birmingham, Ala.
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Care in design and manufacture can reduce defects in rolls . . . . roll life is extended and better product is produced.

Material and Design Defects In Forged Steel Rolls

by A. A. BRADD,
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ROLLS bear the responsibility for a large part of the success of any rolling operation. Both the quality of the product rolled and the rolling costs are directly related to roll performance. The increasing trend toward more stringent surface requirements in rolled products, the rolling of harder and more difficult alloys, and the effort to obtain more economical production by increasing rolling speeds and more efficient grinding practices have required parallel efforts by the roll makers to produce a product that will satisfy the user's needs.

There are few if any engineering parts that have as varied and severe requirements as rolling mill rolls. They are undoubtedly among the most highly loaded in service of all products. Many rolls are subjected to service loads that are well above their endurance limit. Surface finish requirements frequently approach optical levels. Wear and abrasion resistance and high hardness are often combined with the conflicting need to have the ability to withstand severe shock loading and at the same time to respond to shotblasting to produce a uniform and reproducible pattern that does not wear smooth too fast.

This paper outlines the production steps in the manufacture of a roll and describes how some defects get into roll material. It will also give a few examples of how these defects can affect roll life and performance. New melting processes are being used to make roll steel and the improvement that can be expected in material made by these new melting methods are mentioned. Design features can also have an important bearing on roll performance and some examples of how simple design changes can sometimes result in marked improvement will be described.

Many of the defects to be discussed are very much the exception rather than the rule. The great majority of rolls are free from harmful defects and give entirely satisfactory service.

MELTING

The basic and probably most difficult to control process in the manufacture of any steel product is the melting operation. An otherwise perfect roll would be useless if it contained nonmetallic inclusions that produced unacceptable surface blemishes on the rolled product. Clean steel is essential for good rolls and all melting efforts should be aimed at producing steel with maximum cleanliness.

The subject of nonmetallic inclusions in steel is a very complicated one. Nonmetallics in steel come from two general sources. Molten steel is in contact with refractories in the furnace and in the ladle and chemical or mechanical reaction with the refractory can result in the steel becoming contaminated. The molten stream of metal from the furnace to the ladle and from the ladle to the mold is in contact with air and oxidation of the surface by the air can introduce oxides into the steel. These oxides and the refractory material constitute one type of inclusion source. The second source of inclusion is the result of reactions from within the steel itself or from additions to it and from changes in solubility while the molten steel is cooling and solidifying. Sims[1]* has shown that nonmetallic particles present in molten steel will rise very rapidly because of the difference in density between the nonmetallic and the steel. For instance, a particle 0.004 in. in diameter will rise at the rate of 2 fps. The larger the particle the faster it will rise. There is fairly general agreement that most inclusions which result from refractory con-

* Numbers in parentheses refer to Bibliography at the end of this paper.

tamination come from around the spout of the ladle and from the spout itself, as the steel is poured from the ladle to the mold.[2] Any refractory contamination that occurred previously and did not dissolve will have had sufficient time to float out of the steel. The stream from the bottom of the spout becomes oxidized as it passes through the air. A layer of oxide material is also likely to be present on the rising surface of the steel in the mold. The falling stream carries refractory and oxide inclusions deep into the mold and also drives some of the surface material underneath.

The second source of inclusions result from the oxidation products of Al, Mn and Si added as deoxidizers at the end of the heat. These elements have a strong affinity for oxygen and they can become oxidized while the stream is passing through the air from the ladle to the mold. Sulphides have high solubility in liquid steel and low solubility in solid steel. They, therefore, precipitate as the steel solidifies. Deoxidation practice has an important effect on the size and shape of the precipitating type of inclusion. The cooling rate of the steel also affects their size. Larger inclusions normally are associated with large ingots that cool slowly. There are, therefore, two types of inclusion material in the mold as the steel starts to solidify. One type is present as distinct particles that rise very rapidly. The second type is in solution in the molten steel and is precipitated as the steel solidifies.

The steel in the mold freezes most rapidly at the surface. The inclusion material that exists as distinct particles and is rising very rapidly would most likely be trapped at the surface of the ingot. The steel cools at a progressively slower rate away from the mold wall. Large inclusions would be expected to have enough time to float out of the usable portion of the ingot as a result of the slower freezing rate away from the surface. It could be anticipated that this type of inclusion would tend to be largest near the surface and at the bottom of the ingot and become progressively smaller toward the center of the ingot.

The type of inclusion that precipitates out of solution in the steel as it solidifies tends to become progressively larger with slower cooling rates. This type of inclusion would be expected to be smallest at the surface where the cooling rate is the fastest and largest at the center of the ingot where the cooling rate is the slowest and maximum time is required for solidification to take place.

Of course, this is an idealized description. Actually there is turbulence in the mold because of the stream of steel falling from the ladle, and occasionally large inclusions that were present in the liquid steel are carried to inner parts of the ingot and are trapped there by the freezing metal. Back pouring after a considerable quantity of inclusion material has floated to the top of the ingot would be an effective way of driving the inclusions back into the ingot and should be avoided where clean steel is required.

The surface of roll ingots will, therefore, be the most likely place for one type of large inclusions to be found and sufficient cut must be made when machining the forgings to remove this surface zone to avoid the presence of gross inclusion bearing material in the finished roll.

By similar reasoning, the second type of large inclusions are likely to be formed at and near the center of the ingot. This is particularly true of medium and large ingots where the cooling rate becomes quite slow and there is ample time for inclusions to grow to a large size. This is one of the reasons why we bore our larger rolls. The bore removes the material that is likely to contain large inclusions. It also removes center segregation, looseness and other possible defects. Table I shows the bore diameters that we have been using for several years where the roll design permits the relationship shown to be used. If the journals are too small to permit a bore as large as that shown on the table, or if the roll is to be remade later into a smaller design where a smaller bore is required, smaller bores than are shown on the table are used.

TABLE I
Recommended Roll Diameter-Bore Diameter Relationship for Forged Steel Rolls

Roll Diam, in.	Bore Size, in.	Roll diam, in.	Bore size, in.
10–11	1 3/4	23	4 3/4
12	2	24	5
13	2 1/4	25	5 1/4
14	2 1/2	26	5 1/2
15	2 3/4	27	5 3/4
16	3	28	6 1/2
17	3 1/4	29	6 3/4
18	3 1/2	30	7
19	3 3/4	31	7 1/4
20	4	32	7 1/2
21	4 1/4	33	7 3/4
22	4 1/2	34	8

The previous discussion covers the source and location of inclusions. What effect do they have on roll service? There appears to be general agreement among those who have studied this problem that it is the oxide type inclusions that are most likely to nucleate fatigue failures.[1], [3] Sulphide inclusions do not appear to be considered as a cause of fatigue failures in steel. However, sulphides lower impact strength and ductility and are undesirable from a surface cleanliness standpoint. Sulphides are most objectionable when they occur in the form of stringers.

Figure 1 — Fractured surface of backup roll sleeve split in service. The failure originated at large nonmetallic inclusions located under the rolling surface.

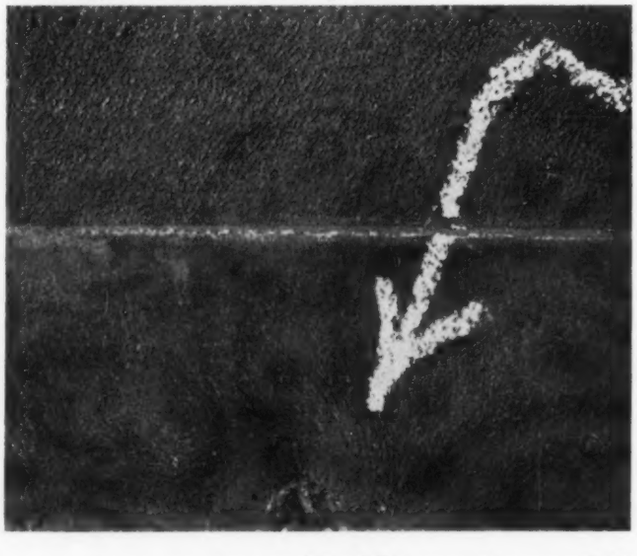


Figure 2 — This 15½-in. diam roll failed from fatigue fracture originating in defect on bore.

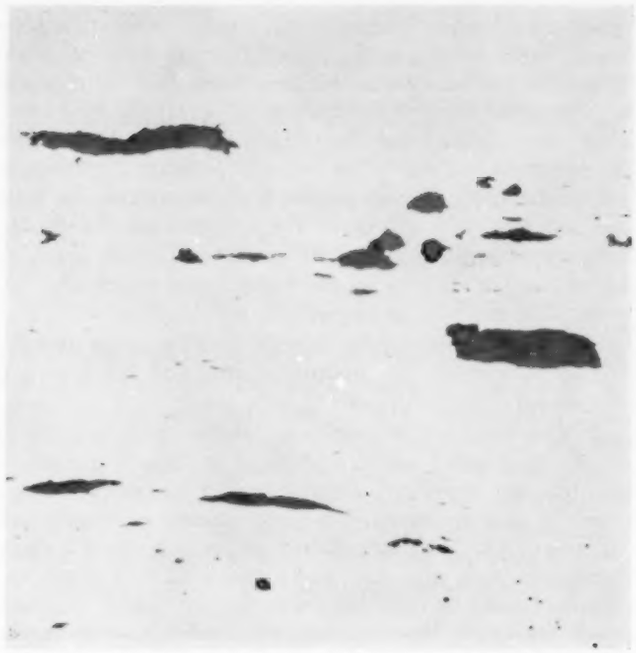


Figure 3 — Nonmetallic inclusions on surface of foil mill roll. Roll was scrapped because of surface defects (100X unetched).

Figure 1 shows the fractured surface of a backup roll sleeve that split in service after very short life. The failure originated in large nonmetallic inclusions that were located about ⅛ in. under the rolling surface. The inclusions nucleated a fatigue crack that progressed about one-fourth through the thickness of the sleeve and when the remaining section was too weak to withstand the working loads, the rest of the fracture was sudden. This is the type of inclusion that normally would be expected to float out of the steel before it solidified.

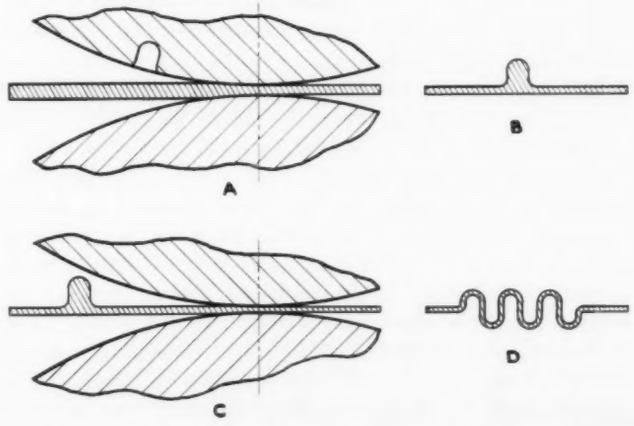
Figure 2 shows a section through a 15½ in. diam roll that was taken out of service because the user heard it making noises in the mill. The roll was found to be cracked from the bore to within about 1 in. from the surface. The fracture was progressive having started at a defect on the bore. This roll was made in 1951, before sonic inspection of all rolls was made a standard practice. A similar defect would undoubtedly be located by sonic inspection today.

Figure 3 shows the as polished micro-structure of a section taken from near the surface of a foil mill roll that was scrapped because it contained large surface defects that made it unfit for foil service. The inclusions are probably ladle or spout material that was trapped near the surface of the ingot before it had time to float out.

For those without actual foil rolling experience, it is sometimes difficult to appreciate how harmful a small surface defect can be in a foil roll. Figure 4 shows schematically how a small inclusion can affect foil rolling. Normally, the inclusion would be pulled out of the roll surface by the grinding wheel when the roll is ground, leaving a small cavity. If the cavity has sharp edges, it can produce small tears in the foil. When the part of the roll containing the cavity passes over the foil, as at A, it leaves a small bump on the foil, B. On the next pass, C, this small bump is rolled flat and as the amount of reduction is greater than for the surrounding material, a wrinkle is produced, as at D, where the bump was located on the previous pass. Very often the wrinkle will be perforated. The size of a defect that can produce a wrinkle in foil being rolled to less than 0.0005 in. thick can be quite small. An insidious thing about this is that the defect in the roll and the bumps on the foil may not be noticed until after a lot of expensive scrap is rolled.

Another extreme example of the need for defect free rolls when processing foil was shown when a mill was pack rolling bright finished aluminum foil 0.00035 in. thick. Two layers of foil were passed through the mill at one time. Mirror finished rolls were used and the outside surfaces of the pack were bright. The inside surfaces of the foil, which were pressed together as the foil went through the mill, came out with a matte finish. Where a defect in the roll was present, there would be no pressure under it and a bright spot would be left on the matte surface. In one batch of foil that was rolled in this way, a recurring pattern of 54 bright

Figure 4 — Schematic representation shows how a defect in a roll affects foil rolling. The defect in the roll, "A," produces a bump on the foil, "B." When this is rolled out "C," the amount of reduction is greater than for the surrounding metal and a wrinkle is produced, "D." Very often the wrinkle is perforated.



spots was found. These bright spots were traced to nonmetallic defects in the rolls. Many of the spots were caused by defects 0.002/0.003 in. long. The largest one was 0.018 in. long. The amount of scrap produced ran into a four figure loss before this trouble was discovered. The purpose for which the foil was to be used permitted no bright spots on the matte side. Defects in the rolls are not the only source of bright spots on the matte side of pack rolled foil. Dirt on the foil, blow holes or other casting defects in the ingot from which the foil was rolled can also be responsible for this trouble.

Consumable electrode vacuum melting looks promising as a method for manufacturing foil rolls with a minimum of harmful defects.

In the consumable electrode vacuum melting process for making steel, an aircast ingot is forged, annealed, conditioned to remove all scale and oxide and this electrode is then remelted in a high vacuum averaging five microns, into a water-cooled copper mold. Oxygen, hydrogen and nitrogen gases are removed from the drops of steel as they fall from the bottom of the electrode through the vacuum. No refractory material is present to contaminate the steel and no additional oxides are formed since the steel does not fall through oxidizing air as air melted steel does when it falls into the mold. With oxides and contaminating refractory absent as sources of inclusions, steel made by this process can be expected to be exceptionally clean. This has been found to be true in rolls made by this process. The cleanliness of rolls made from consumable electrode vacuum melted steel has been found to be an order of magnitude better than we normally find in air-melted steel rolls. In the foil mill described above where defects as small as 0.002 in. long in air-melted rolls produced bright spots on the foil, no defects in the foil rolled on consumable electrode vacuum melted rolls have been traced to defects in the rolls. This is a very severe test for the presence of surface defects in the vacuum-melted rolls and they appear to have passed it very successfully.

With fewer and smaller oxide type inclusions and greater toughness because of the lower hydrogen content, one would expect fewer nuclei for fatigue fracture and greater resistance to spalling in the vacuum-melted rolls compared to air-cast steel. The consumable electrode vacuum-melted rolls that we have made have not been in service long enough to develop any comparable data against air-melted rolls. However, bearing manufacturers,[4] have run extensive life tests to compare air-melted bearing steel against vacuum-melted bearing steel. Bearings fail by spalling, very much like rolls. It is our understanding that vacuum-melted bearings consistently show about double the life compared to air-melted bearings.

Rolls made from consumable electrode vacuum-melted steel have shown advantages in grinding over air-melted rolls. This will be described later.

Vacuum pouring facilities have recently been installed in our works. In this process, steel is melted conventionally in basic electric furnaces and is then poured through a small pony ladle into a vacuum chamber where the ingot mold is placed. The vacuum in the chamber is maintained at about 600 microns. The stream from the pony ladle falls in droplets through the vacuum and hydrogen, oxygen and nitrogen gases are removed from the droplets as they fall into the mold. Oxygen is absent around the steel as it falls and few, if any, oxides are present on the surface of the metal as it rises in the mold. One would, therefore, expect the steel made by this process to be much cleaner than air cast steel. We have not yet made enough vacuum cast rolls to arrive at a definite evaluation of the benefits to be expected from the vacuum casting process. We do expect that it will produce cleaner rolls with fewer and smaller inclusions and greater resistance to spalling than air cast rolls.

FORGING

Forging operations must be carefully controlled to avoid introducing any harmful effects in this stage of roll manufacture.

Heating rates must not be excessive. If a forging is heated too rapidly, the outside will expand thermally before the inside is heated through. This can put a heavy tensile stress on the inside of the forging and has sometimes resulted in internal fracture known as "fire cracking." Heating rates must be carefully controlled to avoid this type of damage.

The forging temperature must not become too high. Roll steels tend to be stiff at forging temperature and the tendency to overheat them must be resisted. If a roll steel, like any other steel, becomes overheated, burning can result. A troublesome thing about the burning of roll steel is that it can occur near the center of the roll with no visible damage on the outside. A roll that has been internally burnt is readily detected by sonic inspection and would usually fail during the drastic quenching of the hardening operation. There is very little chance for a burnt roll to survive long enough to get into service.

The amount of forging reduction used to make rolls is sometimes arrived at by compromise. Sufficient reduction is required to consolidate the center of the ingot. At the same time, too much reduction could result in stringing out inclusions to objectionable lengths. Stringer type inclusions with sharp ends can be more harmful than shorter ones with rounded ends. When the shape and size of inclusions present a special problem in making a roll forging, the forging reduction used is designed to fit the special requirements.

Care must be taken during forging operations to avoid the formation of laps or folds that would leave decarburized and oxidized surface material under the finished surface of the roll.

Surface cracking during hot working is occasionally a problem when forging rolls. It is very likely that subsurface nonmetallic inclusions can be responsible for this type of defect.[5] When surface cracking occurs, the forging must be scarfed to remove the cracks or sufficient stock must be left on the forging to be sure that a roll of the specified size can be made from it after the crack is removed. If surface cracks do not clean up when a roll is finish ground, the roll cannot be used. Figure 5 shows a crack found on the surface of a finished roll that was scrapped because of the presence of the defect. This is the typical appearance of a defect resulting from leaving insufficient stock on a roll forging. Enough top and bottom scrap should also be cut from the ingot to avoid any defective material from the top and bottom of the ingot being made into part of a roll.

Figure 5 — Surface defect is typical of the type that results from leaving insufficient cut on roll forging (unetched 100X).

ANNEALING AND PRELIMINARY TREATMENT

After the forging operations are completed, rolls are taken while still hot and are charged into heated annealing furnaces for annealing and conditioning treatments.

Flake prevention is a very important part of the annealing cycle and for large rolls very slow cooling rates and long holding times may require weeks before a roll forging is safely brought to room temperature. Flakes are readily discovered by sonic inspection. A flaked roll would rarely survive the high stresses produced by spray quenching during hardening. With vacuum pouring of large roll ingots, the possibility of producing a flaked roll will be reduced to an absolute minimum.

Another purpose of the preliminary treatment is to produce a micro-structure most suitable for subsequent hardening. A heavy continuous carbide network structure would be particularly poor at this stage.

The final journal hardness is determined at this stage of production for many rolls. On work rolls used in four-high mills the backup rolls take most of the load and the journal hardness and strength is not too critical, as long as sufficient strength and wear resistance to prevent excessive wear on the journals and to withstand the driving torque is present. The journals of backup rolls and work rolls in two-high mills are sometimes subject to very heavy shock loads and special care must be taken in the preliminary treatment to produce the required strength and impact resistance in the journals. Design has an important part in this problem. A few examples of how changes in design can help prevent neck failures will be given later.

Normally rolls are quenched and drawn to produce the required journal hardness. On smaller rolls this is done before they are machined. Larger rolls are rough machined and bored before treatment. A 40–50 scleroscope hardness range has been found to be suitable for most roll necks. Harder journals, usually in the 50–65 scleroscope range are specified when higher strength or increased resistance to wear is required. On some rolls where roller bearings operate directly against the necks with no inner race, journal hardnesses of 80–90 scleroscope and higher are required. The hardness of these journals is usually produced at the same time as the body of the roll is hardened, not in the preliminary treatment stage.

MACHINING FOR HARDENING

After preliminary treatment, rolls are machined for hardening. The benefits of good judgment and experience are very helpful at this stage to be sure that sufficient stock is left on the forging so that the roll can be finished with no decarburized metal present.

TABLE II
Minimum Bevel Requirements
(Normally 45-degree bevels are preferred when the roll design does not include a long taper from the end of the body)

Roll diam, in.	Bevel, in.	Roll diam, in.	Bevel, in.
Up to 4	1/4	9–20	1/2
4–6	5/16	20–28	3/4
6–8	3/8	Over 28	1
8–9	7/16		

At the same time too much excess stock on the body should be avoided. The outer surface of a hardened roll body contains the most effectively quenched part of the roll. If too much material is ground off to reduce the body to the desired diameter, less of the usable hardened outer layer will remain and less usable reduction will result. However, on all rolls we allow a minimum cut for grinding after hardening to be sure that all decarburization, scale and pits are removed before the roll is ready for use.

End spalling is a problem when hardening rolls. We have found that 45-degree bevels appear to be the best design to avoid end spalling with our hardening practice when the roll design does not include a long taper from the end of the body. Table II shows our standard minimum bevel requirements for hardening. Whenever possible, it is advisable to ship rolls with similar bevels to avoid the need for grinding off excess metal and the possibility of producing residual grinding stresses on the ends of the body.

HARDENING

The surface hardness requirements for rolls are usually given as a Shore scleroscope range, although Rockwell, Penetrascope, D.P.H. and Brinell are also used. It is general practice to allow a five point scleroscope range or equivalent when specifying roll hardness requirements. For many years roll makers and roll users were not always sure of the hardness that was actually specified because of a difference in the way that scleroscopes were calibrated. As a result of cooperative effort among the roll manufacturers, roll users and hardness testing instrument makers, the American Society for Testing Materials has issued Specification A-427, which covers the hardness testing of forged steel rolls.

The scleroscopes used to test the hardness of rolls are calibrated in accordance with this standard and it is recommended that all roll users have their scleroscopes similarly calibrated to avoid possible confusion. The C and D type scleroscope do not usually give the same reading when used on the same roll. It is helpful to the roll manufacturer to be given the type of instrument to be used as well as the range when a hardness specification is made.

Forged steel rolls are made with a wide range of body hardness. Some rolls used in nonferrous hot rolling are made as soft as 40 scleroscope. Many rolls used to roll foil, nonferrous metals, and stainless steel are required to be harder than 100 scleroscope. Other rolls are made with hardness specifications inside these limits. Most work rolls are made in the 90–100 scleroscope range. The hardness range for backup rolls varies almost as much as for work rolls. Some backup rolls are as hard as the work rolls used in the same mill and some

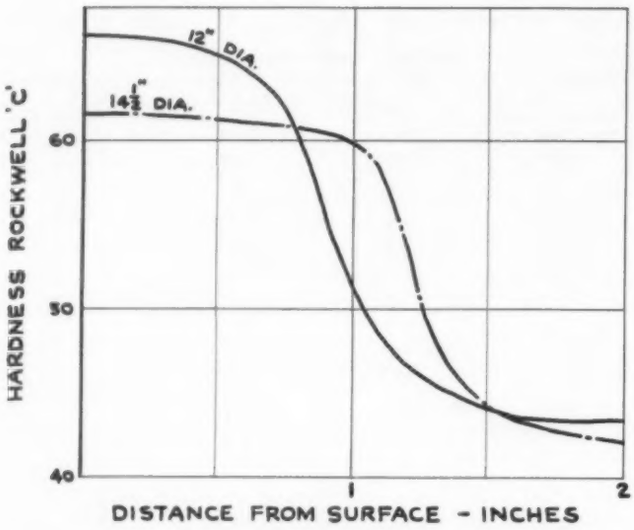


Figure 6 — Hardness penetration taken from 12 and 14½-in. diam production rolls.

are 100 scleroscope hard. In other mills the backup rolls may range from 5 to 50 points softer than the work rolls. The usual average is for the backup rolls to be about 20–30 points softer than the work rolls. If a roll is too soft it will be more susceptible to surface damage, marking and denting and will require more frequent regrinding than a roll of the proper hardness. If it is too hard, it will be more susceptible to damage and more likely to spall if abused in service. The ability to respond to shotblasting is related to surface hardness and sometimes rolls are ordered below the best hardness range for service because the user's blasting equipment requires longer time to produce the desired pattern on harder rolls. We have seen examples of roll life between grinds being more than doubled with harder rolls when the additional time required to produce the blasted pattern was taken.

The depth of hardening in rolls is very important. The potential service that can be obtained from a roll is directly related to the depth of usable hardness. However, it is sometimes undesirable to increase the depth of hardening too much. We find, especially with small rolls, that too great a depth of hardening can result in increased roll breakage both during the hardening operation and in service. We are frequently asked how deep one can harden a roll. In a recently completed series of tests where we hardened roll blanks using different hardening practices, we found that the fully hardened outer layer varied from ⅜ to as much as 1½ in. thick. Figure 6 shows hardness penetration patterns taken from two production rolls.

We can heat our rolls for hardening both in conventional gas furnaces and by electric induction. Most work rolls are quenched in specially designed sprays using many thousands of gallons of water per minute. We normally aim for a fully quenched, fine grained microstructure in our hardening operation. Tempering is done in oil bath and air draw furnaces. Low temperatures and long holds are used for the tempering treatments. In addition to the depth of surface hardening, grain size and hardness requirements that must be met by the hardening operation, it is necessary to produce adequate strength under the fully hardened outer layer so that the roll can withstand the operating loads. The surface hardness must be uniform from one end of the roll to the other. And with it all, the roll must be strong enough and tough enough to withstand the high loads and not infrequent overloads associated with many rolling operations.

FINAL MACHINING AND GRINDING

After a roll is hardened and tempered, its hardness is checked carefully to be sure that it complies with the specified requirements. It is then machined and ground to the required dimensional surface finish and concentricity limits.

Care must be taken in the machining and grinding operations to avoid the presence of sharp tool marks or other stress raisers in highly loaded areas. Where very high neck stresses are to be resisted, cold working of the necks by surface rolling is a useful practice to increase resistance to neck failure. Normally, concentricity limits of 0.0003 in. T.I.R. (total indicated runout) are held on the body and journals of work rolls, unless greater accuracy is specified by the roll user. On large backup rolls and assemblies a concentricity limit of 0.0005 T.I.R. is usually considered to be satisfactory. Grinding must be carefully done to avoid overheating the roll surface and softening it. The residual stresses produced by over severe grinding can be very high and have been reported as exceeding 100,000 psi at and near the surface. Shallow "onion skin" spalls are often the result of improper grinding. The heat generated by improper grinding can soften the surface of a roll and produce "heat checks" or cracks. If a roll is put into service with these cracks present on the surface, they can nucleate a fatigue fracture that can result in a spall.

It is our normal practice to recheck the hardness of rolls after they are finish ground. If a roll has been improperly ground, the heat produced will soften the roll surface and this can be readily detected by the hardness test. Grit blasting and etching with 7 per cent Nital are also effective methods of determining if a hardened steel part like a roll has been abused in grinding.

The rolling of foil, stainless steel, precious metals and high lustre brass mill products often requires the highest possible mirror finish on the work rolls. What is often desired is a "black lustre" finish, so called because the area outside the high lights where light is reflected have a black appearance that is almost three dimensional in quality. With a standard grinding practice some rolls can be ground to the "black lustre" finish very readily. Other rolls are much more difficult to grind to this finish, retaining a white cast in the areas outside the high lights in spite of repeated efforts on the part of the roll grinder.

The reasons for this difference in response to grinding are not clear. Probably the uniformity of micro-structure, grain size, hardness, severity of the dendritic pattern remaining from the ingot structure and size, type and quantity of nonmetallic inclusions are factors involved in the response to grinding. Possibly, the smearing effect of nonmetallic inclusion material pulled out by the grinding wheel and rubbed by it over the roll surface is a reason for trouble in getting the desired finish.

Rolls made from consumable electrode vacuum-

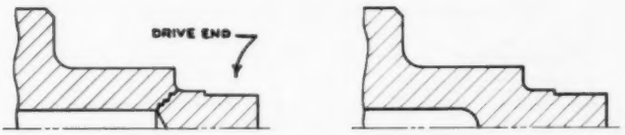


Figure 7 — The design on the left of the drive end of a two-high mill work roll resulted in neck failure when a fatigue crack started at the sharp corner at the bottom of the bore. The revised design shown on the right rounded the bottom of the bore and increased the distance across the weak diagonal section.

melted steel generally respond very readily when they are ground to a "black lustre" finish. This probably results from the very high order of cleanliness of this steel and the very uniform fine grained cast structure resulting from the rapid cooling in a water cooled copper mold. The final polishing operation on mirror finished vacuum-melted rolls can generally be done in 30 to 50 per cent less time than with air-melted rolls and the "black lustre" finish is usually produced with very little trouble.

In one mill where a grinding practice finishing with a 600-grit wheel for final polishing produced a 1 to 1½ micro-in. finish on air melted rolls, the same grinding practice produced ½ to ¾ micro-in. finish on vacuum melted rolls.

DESIGN

Good design as well as good material is helpful in avoiding service failures in highly stressed parts like rolls.

Figure 7 shows the drive end of a two-high work roll with a blind bore. The roll was internally water cooled in service. The bore was drilled with a sharp-cornered drill and the stress-concentrating effect of the sharp corner started a fatigue crack that resulted in the failure of the roll when the drive extension broke off as shown. The location of the bottom of the bore was changed to strengthen the weak diagonal section and a round bottom drill was used to eliminate the sharp corner. The new design has been in service for several years with no failures.

The splitting of backup roll sleeves is a serious and expensive problem. This type of failure sometimes occurs when the bearing housing rubs against the end of the sleeve or something falls between the housing and the sleeve. Figure 8 shows the end of a sleeve that split after the thrust bearing failed to hold the backup assembly in position and the end of the sleeve was severely rubbed by the end of the bearing housing producing a series of radial heat checks as shown. One of the heat checks extended under the shrink and working loads and the sleeve split.

Figure 9 shows how the danger of this type of failure can be minimized. The left hand sketch shows how the sleeve length can be shortened so that additional clearance is allowed between the end of the sleeve and the housing. A greater amount of lateral motion can take place with the increased clearance before contact is made between the sleeve and the housing. Sleeves, that would become heat checked with the short clearance, remain undamaged with the increased space between the end of the sleeve and the housing.

Another possible way to avoid heat checking on the

Figure 8 — End of backup sleeve that split in service shows heat checks that were produced when the bearing housing rubbed against the sleeve. Splitting occurred when one of the heat checks extended under the shrink and working loads.

end of the sleeve would be to assemble a wear ring as shown on the right hand sketch of Figure 9. If severe rubbing were to take place under these conditions, the wear ring would absorb all the damage and the ring could be replaced if necessary with no harm done to the sleeve.

The harmful stress-concentrating effect of sharp corners and small radii are well known and have contributed to many roll neck failures.

Figure 10 shows how a design can be improved by changing the radius. The effective strength of a roll neck can sometimes be more than doubled by increasing the radius.[6] Some rolls are designed with small journal radii because the bearings that are used do not provide sufficient clearance to permit larger radii that would substantially reduce stress concentration to be used.

Figure 11 illustrates how a change in thrust ring design was made to correct a condition that resulted in several neck failures in rolls used in a two-high mill rolling copper alloys. The original design for the thrust

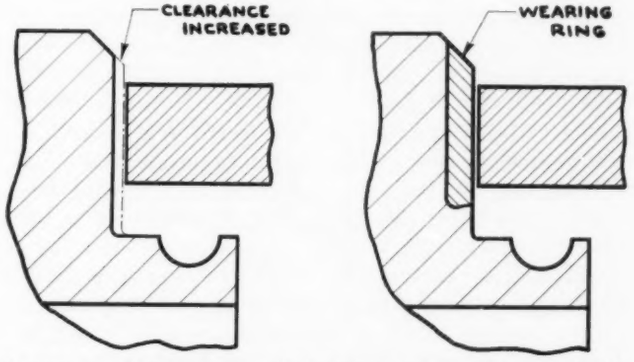


Figure 9 — Methods of minimizing danger of heat checking on ends of backup sleeve. Left, more clearance is provided between bearing housing and sleeve. Right, wear ring is assembled to absorb possible damage and protect the sleeve.

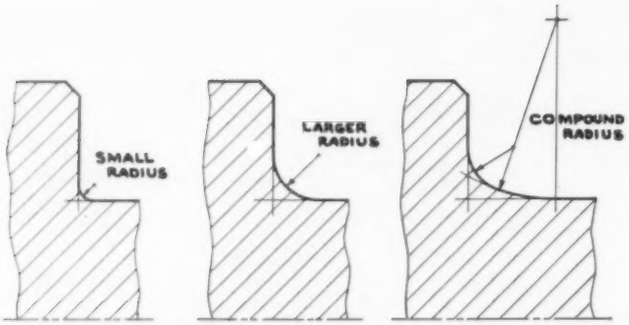


Figure 10 — Increasing the radius between body and journal can materially decrease stress concentration and increase effective strength.

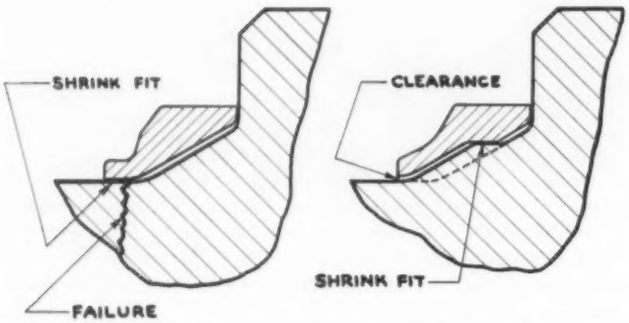


Figure 11 — Left is shown failure of two-high mill roll that occurred when fretting corrosion produced pitting which nucleated a fatigue crack. Right is revised design changing position of shrink fit of location away from most highly stressed part of journal.

ring is shown on the left. It is fairly common. The ring is assembled with a shrink fit on the end of the bearing fit portion of the journal. Sometimes such rings rotate in service, scoring the roll necks. The score marks act as stress concentration points and progressive fractures start that result in the neck breaking off. In this case, the rings did not rotate. The mill was highly loaded and a slight flexing action of the necks in service caused fretting corrosion to start under the thrust ring. This corrosion eventually produced pits that became the nucleii of fatigue cracks and the necks failed.

To improve this condition, the ring was redesigned so that the shrink fit was on a shoulder closer to the body as shown in the right hand sketch. Clearance between the ring and the roll was provided at the base of the radius, so that no fretting would take place if the journal flexed. The diameter of the roll neck under the ring was increased so that the strength was increased by about 10 per cent. In addition, the surface of the taper and the radius was rolled to increase the resistance to fatigue failure. The new design eliminated the weakening effect of the shrink fit on the most highly stressed part of the journal and with the shrink being made on a larger diameter, the resistance to possible rotation was increased.

If roll designers were more fully aware of the effect of fretting corrosion and clamping pressure on strength, they probably would try to avoid the thrust ring design where the shrink fit is on or near the most highly stressed part of the journal. Figure 12 from Sachs[7] shows how fretting action can reduce the fatigue strength of steel. The endurance limit with fretting is 50 per cent lower. Figure 13 shows how the fatigue strength drops

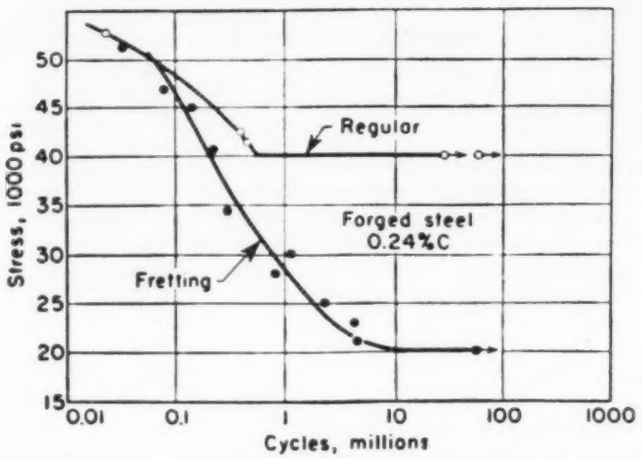


Figure 12 — Stress-cycle curves for tests on fretting fatigue and regular fatigue of a forged steel.

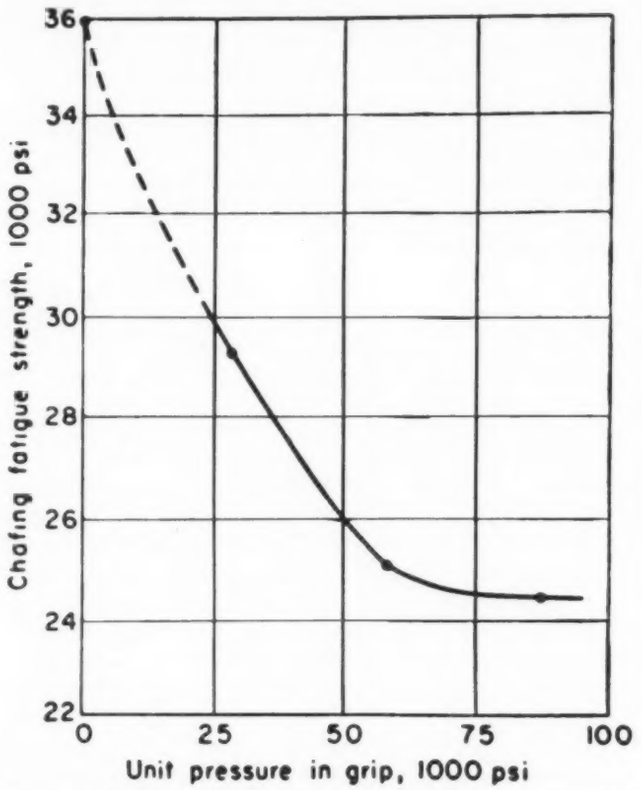
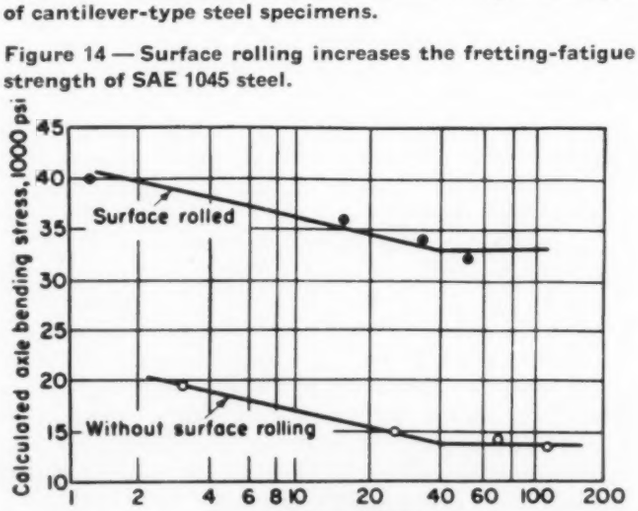


Figure 13 — Clamping pressure reduces fatigue strength of cantilever-type steel specimens.

Figure 14 — Surface rolling increases the fretting-fatigue strength of SAE 1045 steel.



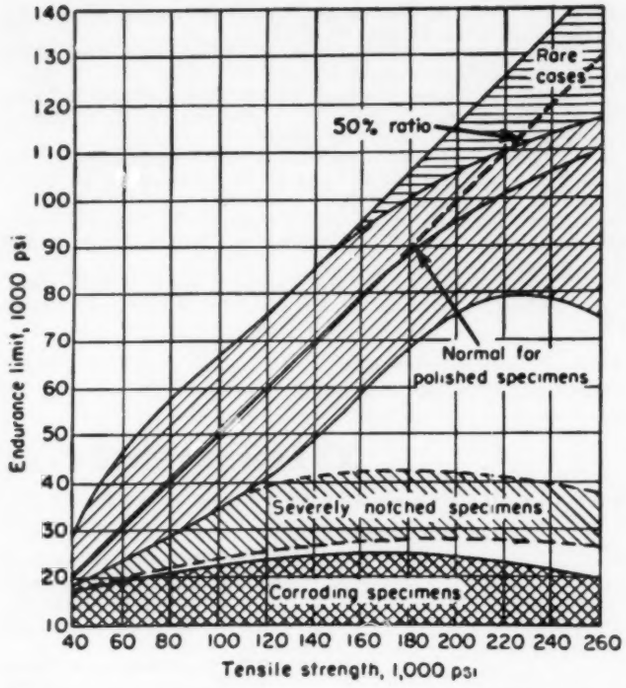


Figure 15 — General behavior in fatigue of steel of polished, notched, or corroding specimens as related to tensile strength.

off very rapidly as the clamping pressure is increased.[7] Surface rolling is an effective procedure to increase the fretting-fatigue strength. This is shown in Figure 14.[7]

The effect of severe notches and corrosion on the endurance limit of steel is shown in Figure 15 from Dolan.[8] The decrease in the endurance limit is very pronounced. If a roll with highly loaded journals has heavy score marks or corroding conditions on the critically loaded areas of the necks, polishing out the score marks or corrosion pits as part of a preventive maintenance program could result in continued use of rolls that would otherwise be likely to fail with broken necks.

GRINDING PRACTICE

While the rollmaker can make every effort to produce a roll free of defects, an important factor controlling roll life and performance is how the user takes care of it. Grinding practice, especially in heavily loaded mills, can be directly related to roll life. Perhaps because the relationship is not immediately obvious, grinding practice is not given as much attention as it deserves in some mills.

The amount of stock removed per grind and frequency of grinding are directly related to spalling problems. As a roll is used, its surface becomes work hardened and residual compressive stresses are built up on the surface. Matching and opposite residual tensile stresses are developed under the surface. If a roll is left in the mill too long, or if insufficient grinding is done to remove the surface stressed material, so that the residual tensile stresses underneath are relieved, the residual tensile stresses under the surface can become so high that when combined with the working stresses they exceed the fatigue strength of the roll and a spall results.

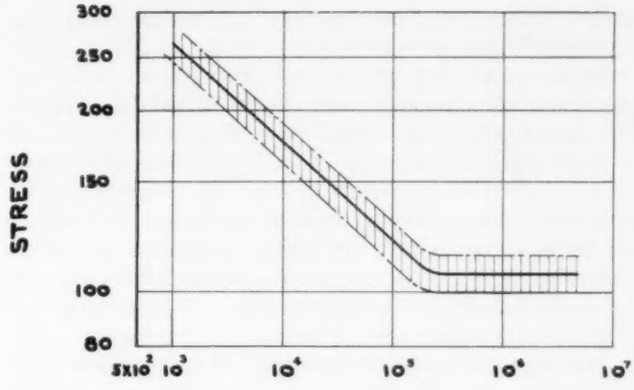


Figure 16 — Typical curve shows relationship between stress and cycle to failure for steel.

Figure 17 — Typical spall near edge of rolling surface of backup roll.

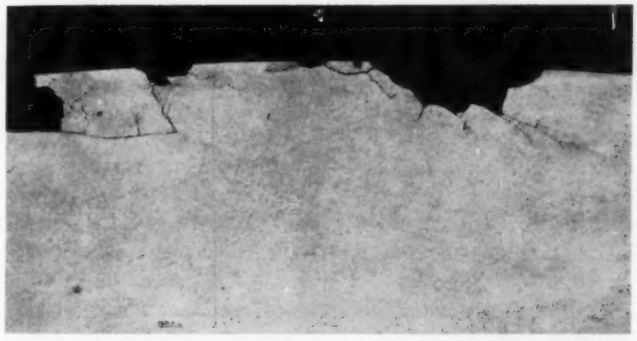


Figure 18 — Cross section through spall in backup roll.

An example of how this works in practice was shown in an aluminum foil mill. In this mill a practice of regrinding the backup rolls every 1500 hr removing 0.050 in. from the body diameter had been followed for many years. No spalling of backup rolls had been experienced. During a period when there was need for more grinding capacity, it was decided to take only 0.020 in. off the roll diameter per grind. After this practice was adopted, three backup rolls were lost because of spalling in a period of less than a year. The original practice of removing 0.050 in. per grind was

then resumed and no spalling of backup rolls has occurred in the last seven years.

Many other examples of how insufficient reduction per grind or excessive items between grinds have resulted in spalled rolls can be cited. Figure 16 is a typical S-N diagram for steel, showing the relationship between stress and cycles to failure.[3] The steel represented by this curve can be loaded indefinitely below 100,000 psi without failing. Above 100,000 psi the time for failure decreases rapidly with increasing stress. Many rolls are loaded in service to stress levels that will produce failure if continued indefinitely. If too much time is allowed between grinds the failure time will be reached and spalling will occur. The diagram is plotted logarithmically so that a small decrease is accompanied by marked increase in the number of cycles to failure. If the stress is reduced below the endurance limit, the roll could be used indefinitely without failing.

End spalling of backup rolls and sleeves is a serious problem in some mills. Figure 17 shows a typical spall of this type. From the S-N diagram it can be seen that the spalling can be prevented if the load on the spalled area is reduced or the time between grinds is shortened so that the combination of time and load do not reach the failure line. This can be done by relieving the ends of the backup roll or crowning its surface so that the load on the area where spalling takes place is reduced or by more frequent grinding so that less time elapses before the highly stressed surface material is removed, and lower residual tensile stresses are developed under the surface. The effect of decreasing the residual stress would be to increase the number of possible stress reversals before failure would occur.

When grinding out surface spalls, it is important to remove all cracked metal. Figure 18 shows the cross section through a backup roll that spalled. If any of the cracked material remained after the spalls were removed, they would act as sharp notches and could lower the fatigue strength to a very low level, as shown on Figure 15, and the crack would continue to grow very rapidly. Many rolls have been scrapped because insufficient stock was removed after a spall was ground out to completely remove all cracked or damaged metal.

SUMMARY

We have attempted to describe some of the defects found in forged steel rolls and how they may affect roll life and the product rolled. In addition, we have tried to point out some design considerations and the effect of grinding practice on roll strength and tendency towards excessive spalling.

It is hoped that an appreciation is left for the need for combined efforts by the roll designer, the rollmaker and the roll user to produce rolls that will be most suitable for their intended use and will not fail prematurely because of inadequate care after they go into service.

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Discussion

PRESENTED BY

H. E. MULLER, Superintendent, Roll Dept., Indiana Harbor Works, Inland Steel Co., East Chicago, Ind.

A. A. BRADD, Coordinator of Rolls, Midvale-Heppenstall Co., Philadelphia, Pa.

J. I. GREENBERGER, Manager, Far East Operations, United Engineering and Foundry Co., Pittsburgh, Pa.

D. C. HORSMAN, Plant Superintendent, Continental Steel Corp., Kokomo, Ind.

JOHN DUGAN, Vice President—Operations, Ohio Steel Foundry Co., Lima, Ohio

H. E. Muller: 1. Are you of the opinion, as are we, that diamond point hardness testing leads to good correlation between a roll users hardness specifications and the roll suppliers manufacturing control of hardness?

2. Do you believe that roll users would gain an advantage in operations by making their own ultrasonic roll inspections during the course of roll use, in order to discover incipient spalls and to determine the depth of fire cracks?

A. A. Bradd: In reply to your questions:

1. We use the diamond point hardness, Rockwell, Scleroscope and Brinell testing to check the hardness of rolls. We try to use the same method to test rolls before they are shipped that the roll user will employ when he receives them. We have found very good correlation using diamond pyramid hardness test.

As the new ASTM Standards, mentioned in the paper, are used by more mills, we will have less trouble with differences between our tests and those made by the roll user.

2. The use of ultrasonic inspection by the roll user can be very helpful in finding incipient spalls. It is rather difficult to evaluate the depth of fire cracks by this method. However, they can be found by ultrasonic inspection when they are practically invisible to the unaided eye.

In one mill where fire cracks were common, many rolls were lost because it was thought that they com-

pletely ground them out, but actually traces of the cracks were left in the surface when the rolls were put back in the mill. The cracks progressed rapidly under the rolling stresses, and often reached a depth that made it necessary to grind down to scrap diameter to remove them.

After surface wave sonic inspection was made a standard practice when grinding out fire cracks, it was found that removing a few more thousandths of an inch after visible cracks disappeared was necessary to clean up all traces of the cracks. They are losing fewer rolls now as a result of this practice.

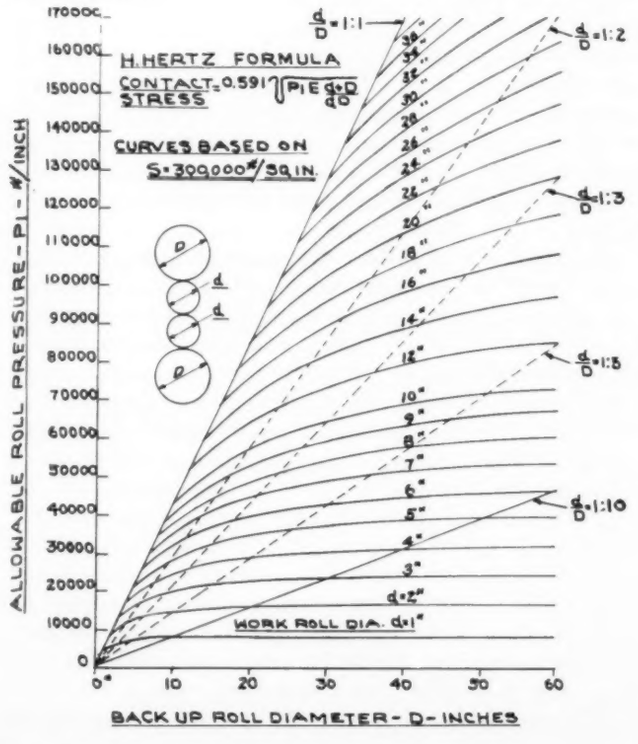
We occasionally find subsurface incipient spalls when we sonic inspect rolls sent to us for rehardening. If the roll user would detect similar subsurface spalls and took rolls containing them out of service, it could result in fewer spalls in the mill, less loss of production, and less chance of damage to the other rolls.

J. I. Greenberger: In addition to the reason stated, it may be pointed out that boring of forged steel work rolls also permits better heat treating of the rolls proper.

It was interesting to note the demands for extremely high purity or clean surface work rolls for foil rolling applications. Undoubtedly, the consumable electrode process provides one means of furnishing these high purity rolls.

Mr. Bradd discussed the importance of using bevels at the ends of the rolls to prevent end pressure and work roll corner failure. It should be noted that the use of proper roll crowning and providing of bevel clearances on work or backup rolls is very important for all 4-high mill applications. Use of proper mechanical clearances between rolls is particularly important where narrow width product is to be rolled on a wide mill. Normal roll deflection under rolling pressure conditions will, in an improperly crowned mill, cause high rolling loads to be interposed between the ends of the work and backup rolls resulting in premature failure. These remarks are only to emphasize that mill operators are directly involved in providing proper roll shaping and clearances so that end rolling of rolls with consequent failure does not occur.

Figure 19 — Contact stresses for various roll diameter combinations.


H. HERTZ FORMULA
CONTACT STRESS = 0.591 √ PIE d+D / dD
CURVES BASED ON S = 300000 #/SQ IN.
d/D = 1:1
d/D = 1:2
d/D = 1:3
d/D = 1:5
d/D = 1:10
WORK ROLL DIA. d = 1"
ALLOWABLE ROLL PRESSURE - PI - #/INCH
BACK UP ROLL DIAMETER - D - INCHES

In addition to providing properly designed roll fillets, our company has for many years been using the practice of cold rolling fillets of critical rolls. In addition, we sonic test rolls. From a design point of view, the comments regarding use of shrink rings on work rolls with attendent difficulties could be amplified. In recent mill installations there has been a definite tendency to eliminate these fillet rings entirely and incorporate the fillet collar as an integral part of the roll design. With even the most perfect roll, it would be well to realize that certain physical limits must be adhered to. In a 4-high rolling mill, the contact stresses setup by the rolling pressure can be the direct cause of spalling and roll failure. Figure 19 shows the calculated contact stresses by the Hertz formula as setup between work and backup rolls of various diameters. Note the allowable roll pressures and pounds per inch of width for various roll combinations. These particular values are based upon maximum contact stress of 300,000 psi. Experience has indicated that rolling conditions which limit these contact stresses below this value are satisfactory to prevent premature spalling and roll failure.

The subject of periodically removing the cold worked skin of a backup roll is most important. For best performance the time a backup roll is kept in service is dependent on the type of operation and tons of steel rolled. This is best determined by mill experience. On hot and cold strip mills, we advocate a maximum of 18 turns for steel rolling.

Normal maintenance should consist of grinding an average of 0.035 to 0.045 in. on diameter per dressing, or whatever is required to clean up the surface. After two grindings, a $\frac{1}{8}$-in. diameter cut should be taken in a lathe. This last procedure *is a must* as it eliminates all cold working which is present as a surface layer on the working face of the roll and also changes the lines of high stress concentration which are located below the surface and cause subsurface fatigue.

A. A. Bradd: We stated in the paper that one reason for boring rolls was to remove possible defects in the center of the roll forging. When we harden a roll, we quench the bore as well as the outside, and it certainly gives a better heat treated structure than we would have without bore quenching.

We did not suggest that fillet rings be used on work rolls. Our suggested use of a shrink ring was on the ends of backup roll sleeves that might be rubbed in service causing the formation of heat checks. These heat checks could result in the loss of the sleeve by splitting. Our suggestion was to use wear-rings on the ends of such sleeves, so that any heat checking would be on the ring and not on the ends of the sleeve. The wear ring could be replaced if it became heat checked, with no damage to the sleeve.

Your comments about the need for proper roll shape, and the necessity for periodically removing the cold worked surface layer of backup rolls are in agreement with the thoughts expressed in the paper. Too

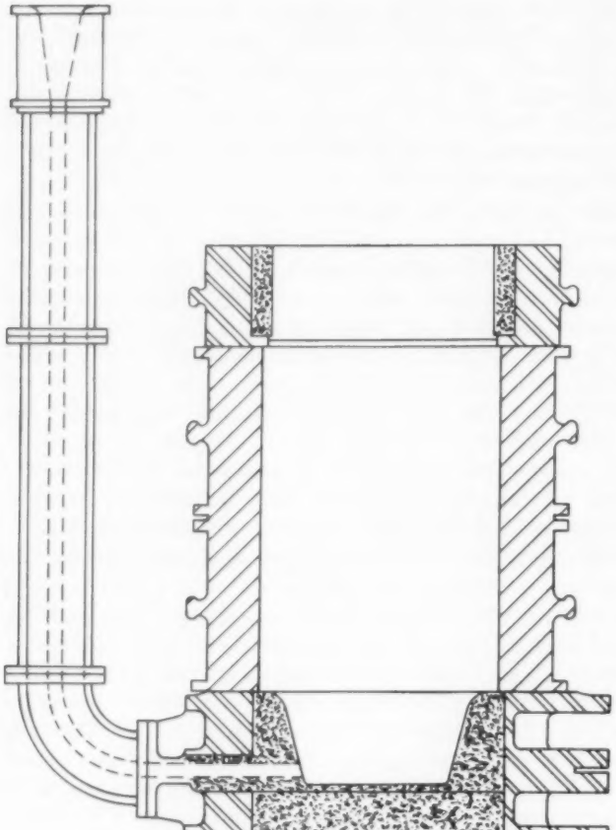


Figure 20 — Diagram shows mold arrangement.

Figure 21 — Picture shows actual mold.

little attention is given in some mills to the effect of the high residual stress pattern produced by excessive cold working. Cold working produces a compressive stress on the surface; and when that is present, there must be a balancing residual tensile stress under the surface. If the residual tensile stress under the surface becomes larger and larger, eventually it will reach the failure line shown in Figure 16, and a spall will result.

D. C. Horsman: As the question of vacuum melting was touched on briefly, I would like to inquire what size or weight limitations are imposed by your facilities for vacuum melting and pouring.

A. A. Bradd: Our present consumable electrode vacuum melting installation will make an ingot weighing about 9300 lb, 21-in. in diameter. Any roll that we make by that process would have to come from that ingot. We usually think that a 7000-lb roll is about the largest we can make at this time.

As for vacuum pouring, we can make the largest roll in use today from a vacuum poured ingot.

John Dugan: The section concerning the nature and occurrence of metallic and nonmetallic inclusions is a good summary of steel melting chemistry. With regard to the trapping of inclusions sometimes at most undesirable locations in the ingot, we think some departures from standard ingot making practice can result in an improved ingot product. Quoting from the paper, "The falling stream carries refractory and oxide inclusions deep into the mold and also drives some of surface material underneath."

We have devised a special ingot mold (Figures 20 and 21) which is poured through a bottom gate. This gate enters the mold cavity tangentially to the mold circumference and is necked down at the entering point to provide a nozzle effect. The metal rising in the mold develops a rapid swirling action which carries the inclusion material to the center and eventually to the top of the ingot.

The paper reviews the problem of formation of large inclusions at the center of the ingot and their final location there, after the completion of forging operations.

Another major reason for boring forged rolls is to permit temperature reduction during surface quenching by means of an auxiliary bore quench when a through heating process prior to quenching is employed.

Precautions must be taken in bore quenching so that defects may not be caused which could lead to eventual roll failure. Figure 2 in the paper shows a macroetched specimen of a 15½-in. diam roll which failed due to cracking which originated in the quenched center bore.

Cracks of this kind might originate at a bore surface inclusion or they might be a result of the quenching operation. If an inclusion was the primary cause of the cracking, the condition could be aggravated by the quenching action. Unfortunately some of these center bore cracks are so small they are difficult to detect by sonic or boroscope inspection and such rolls may at times get into mill service which repeated stressing may cause the cracks to become extended and eventually roll failure results. Figures 24 and 25 show the development of a bore crack which led to roll failure.

All remarks on foil mill rolls are quite pertinent and

Figure 22 — Macroetched specimen shows forged roll which has been quenched at the center bore.

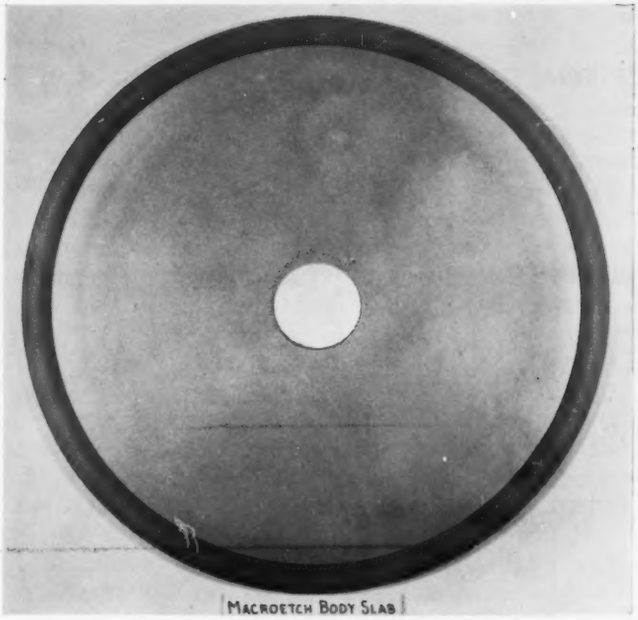


Figure 23 — Macroetched specimen shows forged roll which has not been quenched at the center bore.

merit the consideration of all who are concerned with the production of a foil product. The consumable electrode vacuum melting method looks most promising and should produce the highest quality material possible.

Unfortunately at the present time only the smaller sizes of rolls can be produced with existing equipment. The rolling industry should be concerned with the situation that the number of such installations is very limited and in an emergency period probably no rolls at all could be produced by this method. We have investigated the possibility of an installation that could process any size of forged roll now in use and have been quoted a price of $4,500,000 for the installation.

Vacuum degassing methods can provide a steel product from which approximately 70 per cent of the hydrogen can be removed. Also other gases are reduced and inclusion occurrence can be changed and reduced. This method provides some promise for improved quality in a larger number of rolls in the immediate future. Figure 26 is a schematic view of our vacuum degassing system. Figure 27 is an actual view of a heat during the vacuum degassing process.

The concluding section of the paper is a very fine review of spalling causes and of the effects of overloading and repeated stressing.

In most forged rolls we are dealing with a surface area which consists of a martensitic material which is by nature under stress and which, because of hardness requirement, has had only a very low temperature tempering treatment, so we are dealing with a rather brittle material.

It is of utmost importance that the roll metallurgist should have a close knowledge of the mill for which he is writing roll specifications because loading and other operating conditions can vary widely for the same type of mill. The questions, how hard should we specify our rolls and how much penetration of hardness should we have, are frequently asked. Answers to these questions depend upon individual mill operating conditions. There is a marked tendency to want to copy between similar types of mills, and very often word that a certain type or hardness is being used successfully in one mill will cause operators of other mills of the same type to want to specify the same kind of roll. However, operating conditions can vary widely and in this regard the published work of the joint committee of the Association of Iron and Steel Engineers and the Roll Manufacturers Institute deserves close study.

This work shows that wide differences can and do take place in roll surfaces during rolling operations. There is far more nonuniformity of surface profile than

Figure 24 — Development of bore crack led to roll failure.

Figure 25 — Closeup of development of bore crack which led to roll failure.

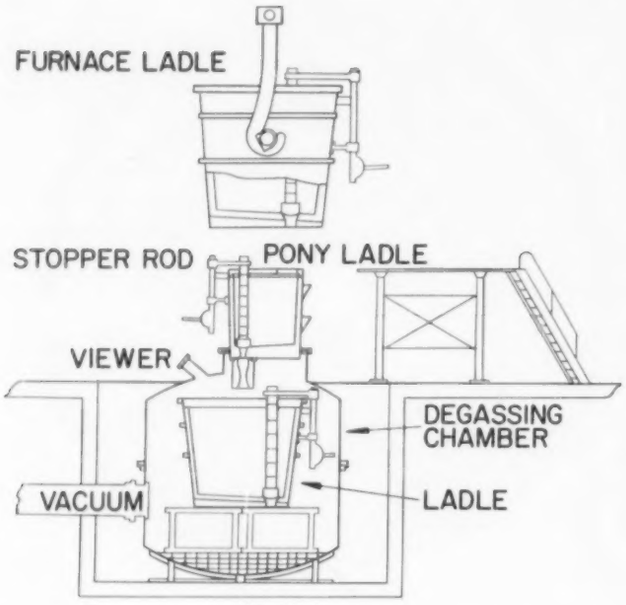


Figure 26 — Schematic view of vacuum degassing system.

Figure 27 — Heat is being poured in vacuum degassing process.

was generally believed and the nonuniformity can cause major overloading. This work shows how the service life of rolls can be greatly impaired when loading in excess of the physical property limits of the roll material occurs.

A. A. Bradd: We will not discuss all of the points brought out by John Dugan; but we agree with him one hundred per cent that to take a roll hardness range that works in one mill, and try to use the same range in other mills is one sure way to get into trouble. Each mill should be studied individually. There are many differences in operating conditions from one mill to another, and they all must be taken into account to arrive at the best hardness range for each mill's operation. ▲

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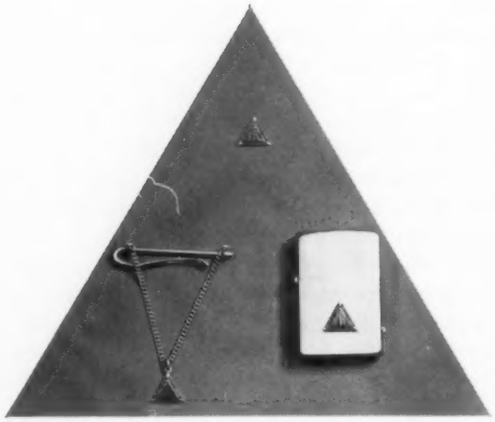


ASSOCIATION OF IRON AND STEEL ENGINEERS

1010 Empire Building **Pittsburgh 22, Pa.**

THE AUTOMATIC STOCKHOUSE

by JOHN F. MEISSNER,
President,
Meissner Engineers, Inc.,
Chicago, Ill.

. . . . the automatic stockhouse is a long step down the road to uniform iron quality . . . .

THE idea of blast furnace stockhouse automation was explored years ago, before that word became one of general daily usage. Unfortunately, the mechanical and the electrical tools now at hand, were then not yet available. The system which is soon to become a reality, which is the subject of this paper, could not have been made possible even a few years back, or made possible only to a limited degree.

The great forward strides in blast furnace practice, especially in furnace production, gave new impetus to the idea, because the assembly and charging of the blast furnace raw materials is already a materials handling problem, and where it is not, it is bound to become a problem in the very near future.

Only a few years ago, when a furnace was producing somewhere around 1600 tons of hot metal per day, it was considered to be doing rather well. Today, the same furnace is expected to produce in excess of 2000 tons per day. Once, 2.5 tons of hot metal per sq ft of hearth area was an acceptable production figure; now, 4 tons per sq ft are expected, and future expectations are raising this figure to 5 and even 5.5 tons.

Doubling the output of a blast furnace, say going from 1600 to 3200 tons of hot metal, is accomplished only through a combination of many things. Among them is the use of beneficiated or high-grade ore and the use of more sinter. However, such increased production, to the same degree, demands an increase in the volume of the raw materials themselves that must be charged, and the problem of charging, that is the mere handling of more bulk volume, is similarly increased or magnified. Rather than call attention to these difficulties, it is more to the point that this discussion deal with the solution of the charging problem, and as well, present a new and up-to-the-minute system or method to perform this routine and ofttimes troublesome, yet important function, and do so in keeping with accelerated demands, promptly, precisely and unfailingly.

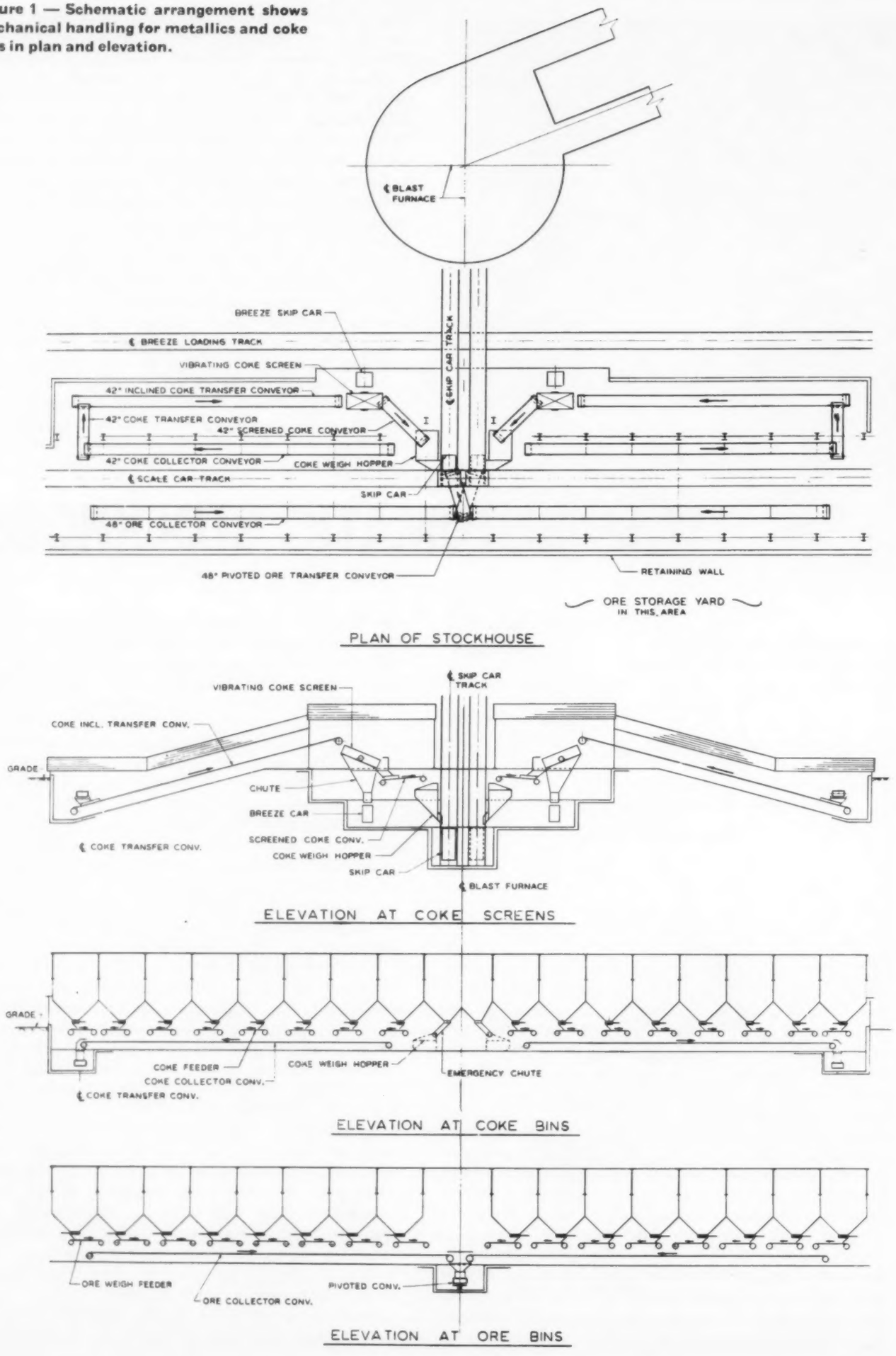
This paper intends to deal more specifically with a system for the automatic assembly and charging of all raw materials, wherein the composition and/or the quantities of the charges is predetermined, and the order to the charges or rounds is previously scheduled, and these functions, integrated with the skip hoist operations, are fully programmed and then carried out uninterruptedly in the proper sequence.

Automatic functions about the blast furnace are by no means new. The operation of the skip hoist, the distributor, the small and large bells are even now automatic functions. The charging of coke, in many cases, has been made an automatic function and if so, it is usually integrated with the skip hoist operation. However, right up to the present moment, there still remains the independent and manually performed scale car operation for the weighing out and the assembly of the metallic and fluxing materials and their delivery to the skip tubs. But the scale car is at last to be eliminated.

The new automatic system can be adapted to a new or to any existing stockhouse. The arrangements of the stockbins in plant after plant bear a marked similarity to one another, in spite of numerous minor differences. The bins may be grouped all to one, or to the other side of a blast furnace, or be more or less divided on both sides. Usually, there are a number of bins in line under one of the highline tracks for the metallic and flux materials, and a similar group of bins under an adjacent track to contain the coke. Some stockhouse arrangements differ, in that so-called central coke bins are provided near the skips. But regardless of the physical differences, these will have no effect on the broad principle that provides an automatic system for handling the metallic and miscellaneous materials, as well as another for handling the coke. The scheme can be tailored to suit any particular plant.

In the new automatic system, a group of lengthwise metallic and flux bins will each be equipped with a

Figure 1 — Schematic arrangement shows mechanical handling for metallics and coke bins in plan and elevation.



weight determining scale feeder. A collecting conveyor, directly underneath, gathers the materials and delivers them to a transfer conveyor which is pivoted and swings in a horizontal plane, and is thus able to discharge into either one of the two skip buckets in their proper turn. See Figure 1.

While the system can be made to suit any arrangement of coke bins, for this discussion assume a similar and adjacent lengthwise group of bins for coke. Each coke bin is equipped with a feeder that communicates with a collecting conveyor running underneath. If coke screening facilities are not already in existence, these can be added.

The coke collecting conveyors, running opposite in direction to the ore conveyors, transfer to cross belts which in turn transfer to inclined conveyors running toward the skips, and finally discharge the coke onto the vibrating screens. The screened coke is directed into a scale mounted weigh hopper, from which it is discharged into the skip bucket at the proper time. This arrangement of conveyors can achieve sufficient vertical height next to the bins to accommodate the coke screen without otherwise sacrificing bin capacity by inclining the belts under the bins themselves.

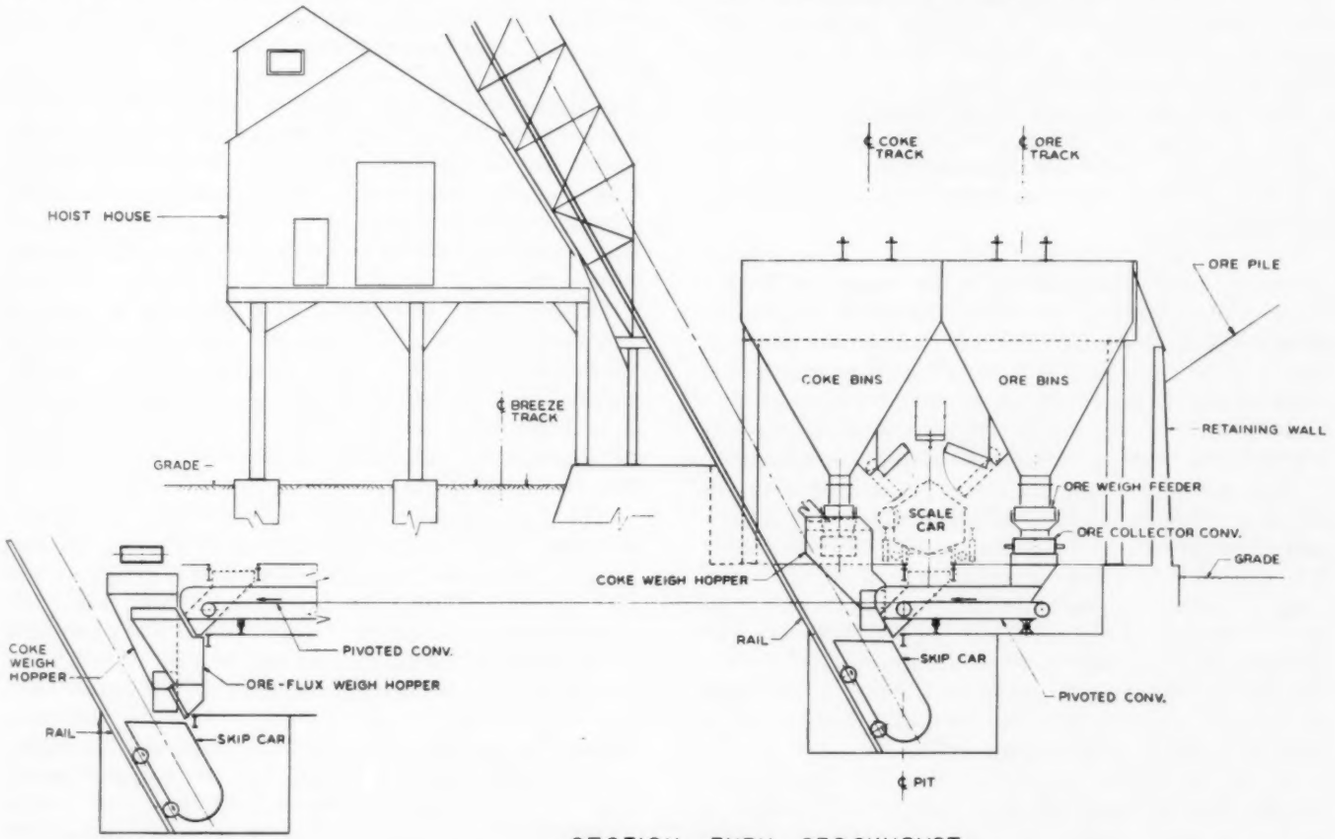
The space under the stockhouse between rows of bins, presently occupied by the scale car, will not be encroached upon. Possible emergency scale car operation is thus provided for, and an important through passageway is also maintained for the scale car itself, so it can travel between furnaces located on either side of the new automatic stockhouse. See Figure 2.

The composition of the blast furnace charges, with respect to one or more kinds of material and the weight for each, as well as the number of charges or draws of metallics and coke, and the desired sequence of the draws in each round, are determined in advance by someone in authority. The complete data is then set up in prescribed form on an appropriate IBM punch card, or on tape designed for this purpose, and the entire charging operation is programmed in advance. If special charges of some material are desired, these too can be programmed on the punch card as to their position in the sequence of draws and the frequency of their occurrence.

When the perforated card is locked in the card-reader, a pushbutton will initiate the entire automatic charging operation; and once started, the system will carry out the programmed functions automatically and uninterruptedly until a change is ordered.

As already mentioned, the input data for a programmed operation is supplied through perforated cards or tape, and an appropriate reader. However, it should be mentioned that the programmed operation can be accomplished as well, where the input data is supplied to the programmer through a panel of setup switches, dials and pushbuttons, especially designed for the purpose. Punch card controlled programming may better serve the purpose, and be more desirable, where a group

Figure 2 — Section through stockhouse bins on centerline of furnace shows mechanical handling units.



SECTION THRU STOCKHOUSE
ON ℄ BLAST FURNACE

ALTERNATE SKIP PIT ARRANGEMENT

of furnaces all in line, are progressively scheduled for conversion to automatic operation so their controls can eventually be grouped or combined. On the other hand, a single isolated furnace may best be served by a programmer which is controlled by a setup switch panel.

In order that it will be altogether clear just what an automatic system will be able to accomplish, and so that its broad scope and unlimited possibilities can better be visualized, it may be well to provide the proper background by looking at some common practices in furnace filling.

An almost standard round can be given as OCC-OSCC/, wherein the "O" designates a metallic draw, "C" a coke draw and "S" a flux draw, the dash "-" a large bell dump without distributor angle change, and the slant "/" a large bell dump with a distributor angle change.

The simple order of a standard seven skip round is sometimes changed to CCO-OSCC/ for four rounds and OCC-CCSO/ for the following four rounds, and then back to the first. There are, of course, many other combinations, too numerous to mention here, which merely illustrates the point. The number of skips per round may also change frequently.

The simple single letter designations should perhaps be elaborated into: Oa, Ob, Oc, to show more than one grade of ore and sinter; further, Sa, Sb and Sc can be used to designate calcite, dolomite and perhaps open hearth slag; while Ca and Cb can designate furnace coke and nut coke. These sub-letter designations will more nearly convey the idea of the actual material make-up of each skip charge and more particularly show the greater number of material variations than must consequently be accounted for in the programming and on the perforated cards.

Operators may resort to "cycle filling," wherein each round is composed differently, with respect to the metallic and flux materials. The combination of any one round is repeated only once every sixth round in a six round filling cycle.

All manner of charges with their almost infinite variations and combinations must therefore be accounted and provided for, and while this may seem to complicate a procedure already complicated, it is in reality little more than collecting the information that must be assembled in any case, and putting it on perforated cards, on tape or on the panel of setup switches, where it will serve as the input data to the programmer.

How the many raw materials are arranged in the stockbins is optional, because the programmed control will allow any bin to be designated for any metallic or flux material. In actual practice, several adjacent bins may contain sinter, several other bins may contain one kind or still another kind of ore, while others will hold flux materials and still others coke, and so on. Each bin will be properly identified as to its contents, as well as to its location, and this information is also made a part of the input data to the programmer.

It will become apparent that one can now log the composition of every charge, namely, the number of materials used separately, or in combination with others; the desired weight of each; the location of the stockbins from which the material will be drawn; the number of bins holding the same materials; determine the number of draws per charge and their sequence, and assemble this information in its proper form on the perforated cards, so that the automatic charging can be instituted. It will become apparent that it is not only the charging of the metallic and flux materials that is automated, but the screening and charging of coke as well, and that all these operations are now to be combined with the cycled operation of the skip hoist, the distributor and the bells, to make a single and completely integrated system and one that is fully programmed.

Whenever a skip car arrives at the loading position in the skip pit, ready to receive material, a charging operation is automatically initiated.

If a metallic or flux charge was called for, the pivoted conveyor will already have been correctly positioned in advance. The pivoted conveyor, the collecting conveyors and the desired feeders will have been started in sequence, also in advance of the arrival of the skip bucket in the pit. Only the scale feeders of those bins, which will contribute material to the charge, will have been selected and started. The quantity in pounds that any one of these feeders must supply to the charge is previously incorporated as a part of the programmed data.

Each feeder is equipped with an electric scale and its control will produce an electric pulse signal for each 50-lb increment of the material withdrawn from the bin. The programmer will count the pulse signals and shutoff the feeder when the programmed weight has been delivered to the collecting conveyor. The feeder contributing the smallest quantity will be the first to stop, and the feeder supplying the greatest quantity will stop last. Starting and stopping of a feeder automatically starts or stops the flow of materials from the bin without any intermediate cut-off gate operation.

The collecting conveyors and the pivoted conveyor will always continue to operate a few seconds after the last and/or the farthest distant feeder has stopped, which will permit these conveyors to clear the charge into the skip bucket. When the pivoted conveyor has stopped, this information is sent to the programmer and the loaded skip car is automatically started in its ascent to the top.

Furnace coke is charged separately in a manner somewhat similar to the metallics, except that the bin feeders will not be weight determining, but merely volume control feeders. A skip load of coke is always held in readiness in each of the two weigh hoppers, to be automatically discharged into the proper skip car at the appropriate time in the programmed sequence.

The programmed control will open the electrically operated weigh hopper discharge gate, when a skip tub has arrived at the loading position and is designated to receive coke. After a definite time interval, when the weigh hopper is empty and when the scale has returned to zero weight, the gate is reclosed, and this through the transmission of proper signals, will start the loaded skip car on its upward trip. At the same time, the coke screen, the transfer conveyors, the collecting conveyors and the coke feeders will start in their proper sequence and will continue to operate until the programmed weight of coke is again contained in the weigh hopper. The control of the weigh hopper load cells will produce an electrical pulse signal for every 50-lb increment of coke entering the hopper and the control system will be capable of counting the number of such pulses, both in

filling and in emptying, and these pulses must equal the programmed weight in either case for the appropriate function to take place. These pulse signals are also essential to the read-out and to provide the signals to the printer for the accumulation of the weight data.

Circle motion vibrating coke screens, most commonly used, have a tendency to coast a short time after the power is shutoff and after the full weight has been recorded in the hopper. To eliminate the consequent carry-over of the extra weight of coke into the weigh hopper, a short belt conveyor is interposed between the screen and the weigh hopper, because the short conveyor can stop instantly. It will therefore accumulate the carry-over from the screen and later deliver this into the next empty hopper. Of the eight coke feeders per side, only two feeders will always start at the same time and in sequenced order, so all the coke bins will be drawn down uniformly. This will aid in unloading strings of coke cars brought up onto the highline. This same feature can be applied to feeders for the metallic and miscellaneous bins, even though most of these materials are ordinarily delivered by the ore transfer car.

Coke breeze made during the screening operation is disposed of by its own handling system. This will be automatic in itself and function independently, and is not integrated with the programmed control.

Scale mounted weigh hoppers for the accumulation of the metallic and flux materials, similar to the coke weigh hoppers that have just previously been described, would be a highly desirable addition to the scheme and could be interposed between the pivoted conveyor and the furnace skips. They could provide a few seconds saving in the time needed to assemble charges and would provide the very desirable feature of a final check on the weight of all metallic and flux materials. Unfortunately, the space in existing stockhouses and particularly the space in existing skip pits is so restricted that it is ordinarily impossible to incorporate this extra feature. See Figure 1.

The furnace will be equipped with two stockline recorders. These should be able to furnish signals to the program control and when either of the probes cannot be lowered to indicate a clearness sufficient for the large bell to dump, the programmed charging operation is suspended. The probe function will be re-initiated automatically after a timed interval and charging will be resumed in exact order after the bell has operated.

The automatic control will include a 24-hr clock giving the minute, hour, day, etc. It will also include the means to accumulate the read-out signals, and punch an eight channel tape, to show the kind of materials and their weights that were loaded into every skip; also the exact time the skip left the pit. The tape reading printer that is included provides a complete, printed record of all skip loadings. In addition to weights and time, the recording will show whether the programmer was on automatic or manual operation, if loading was halted by an empty bin signal, by the stockline probes, or a stop signal from the casting floor, and the duration of the delay. It will also show when extra skips of material were added and the nature of these. The different kinds of material, and the different operations will be recorded on the tape by code letters which will properly identify each.

Charging of furnace water is also made a programmed function. A programmed quantity of water, controlled by a positive displacement meter, will be added only to the skips with metallic materials. When water is called for, and the skip to receive it comes to rest in the pit, a valve will open and the programmed amount, let us say up to 126-gal in 2-gal increments, will be delivered. The programmer also provides for the addition of extra quantities of water as a manual function. Further, a demand for extra water may be ordered by the furnace top-temperature recorder. This will be by means of an analog-to-digital converter to the programmer which will add water when a predetermined temperature is reached, and do so in increased amounts up to a preset maximum and as the temperature increases up to or above a predetermined point.

The control that will guide and carry out all the related and co-ordinated programmed functions and produce a printed record of the charging operation has already been developed. It deserves to be discussed at length and in detail because it is such an important part of the entire system. Since this special subject cannot very well be dealt with briefly in this paper, to do the matter justice it should be discussed in a separate paper. Thus, it may suffice to say here that the complete program control and the motor control as well will be contained in cabinets, which will be conveniently grouped and located in a washed air, pressurized control center.

The first so-called automatic stockhouse using this new charging system, is being installed at a blast furnace in the Chicago district.

If any features of the automatic stockhouse have not been herein discussed, it was done to keep the length of this paper within bounds, and not because of inherent omissions in the design or in the objectives of the system. Every possibility was thoroughly explored during the development of this method, and every worthwhile feature has been incorporated in the mechanical and the electrical system.

SUMMARY

In summary, it can surely be said that another step in the automation of blast furnace operations has been achieved through a system that offers many special features:

1. Completely automatic charging of blast furnaces.
2. Accurate composition of charges.
3. Accurate weight determination of materials entering into the charges.
4. Elimination of errors in weights and in the selection of the materials.
5. Rapidity with which operations are performed and repeated.
6. Accurate read-out of weights.
7. Accurate and complete read-out and accumulation of data covering all charging operations, which can be made available almost instantly.
8. The promise of accurate and useful statistical data never before available, which may lead to even better performance and greater furnace production in the future.
9. The enthusiastic reception this idea has already received from blast furnace operators is most gratifying and may well signal a new trend toward more and more automatic operations, and a widespread conversion to

the automatic stockhouse. Because of our own enthusiasm, we should like to make a prediction that sometime soon, the stockhouse will have lost its now familiar look; that the parallel rows of bins with railroad tracks above and scale cars below, and the highline approach trestle, will be gone. Raw materials will be received from ships, even more automatically, and move automatically and unassistedly to storage piles; there again to be recovered altogether automatically and move on to the sintering plant and/or the blast furnaces. The furnaces will, of course, be supplied with programmed charges of prepared and beneficiated materials, all automatically delivered to the furnace supply bins, which will be clustered about the furnace. The intermittent batch and bucket, that are the skip hoist type filling means, may even give way to a direct and continuous means of raising the materials to the top of the furnace.

Many more new ideas will be brought to bear on blast furnace operations in the future. Quick analyses of the raw materials by x-ray are even now being explored. Before long, we will therefore install x-ray analyzers and electronic computers to more elaborately and more accurately program the composition of the charges, and create a chemically balanced burden, and thus produce even greater quantities of almost perfect grades of hot metal.

Discussion

PRESENTED BY

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JOHN F. MEISSNER, President, Meissner Engineers, Inc., Chicago, Ill.

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J. M. Stapleton: The assembly and charging of raw materials has recently become a task of heroic proportions. Within the past few years, the advent of large quantities of agglomerates and beneficiated ores, along with bigger furnaces and new techniques, have compelled operators and engineers to face the realization that there is little possibility remaining for the expansion of the conventional stockhouse and filling methods. Although the richer and better prepared burdens have compensated somewhat for the filling demands of higher production rates by requiring less coke and containing less water and slag making gangue, along with their pure physical ease of handling, further production improvement dictates a new approach to charging.

At accelerated production rates, existing modern equipment can fulfill the demand only under almost ideal conditions. Irregularities and delays always result in loss of proper stockline maintenance and blast reduction is often the only alternative to restore the proper level.

This new system is not as radical a departure as it sounds. A large number of blast furnace plants now enjoy automatic coke handling, which has been successful for many years, and its projection to metallic bearing materials and limestone is a logical step, especially with sized materials. At least one plant in this country (Fairfield, U. S. Steel Corp.) has gone partially down this route for many years.

The automatic programmed system offers advantages to the blast furnace operator never before attainable under routine operation. These advantages are: (1) an improved uniformity in weighing each increment of every charge, (2) concise filling and maintenance of the stockline, and (3) accurate records of weights of materials charged.

It is interesting to reflect on the additional knowledge the new system will place in the hands of the operator. In removing charging irregularities, basic knowledge will be obtained pertaining to the relative effect of physical and chemical variations in the raw materials. The system removes the human factor from consideration; always difficult to evaluate in furnace performance studies. Furthermore, a new era of quality control in blast furnaces will become available. Through the removal of "stockhouse variations" as one of the blast furnace variables, it now becomes possible to exploit advantageously other constructive efforts toward the attainment of uniform raw materials. We will be a long way down the road to uniform iron quality.

W. H. Collison: An old cliche applied to blast furnaces is "You cannot get out the bottom what you have not put in the top." It is usually applied to the lack of a high level of iron units in the burden, but it may well apply to those furnaces whose rate of productivity threatens to outgrow the conventional charging system. If we consider a furnace of 3000 tons per day, 8000 tons or more materials must be charged. Parenthetically, the Russians have given some consideration to a 5000-ton furnace, and would charge it with belts only. The author has prepared a thought-provoking paper on a system for charging such furnaces with skips and with a stockhouse which resembles the old stockhouse only in the arrangement of bins.

Some engineers specializing in automation have advanced the idea that the solution to this charging problem is the use of a programmed, fully automatic scale car and bin gate system. They argue that the skips cannot be kept stationary long enough for filling; that belts of sufficient capacity are too large and space consuming; that the cost of belt system maintenance will offset the saving in scale car men's wages. While not indifferent to wage savings, as operators we feel the important point

is the ability to fill the furnace, not only normally, but to "catch-up" minor delays without reducing wind. Has the author prepared a timetable of the various operations of a charge which indicates the necessary speed in the system described? A possible but costly arrangement, not requiring large belt capacities, would be two pairs of skips in an "over and under" arrangement, which would permit the charging of a skip while the opposite pair is traveling.

The belt scales or scale feeders must be accurate and must be capable of continuing accuracy with reasonable maintenance. We admit their accuracy could be poor and be no worse than some of our present weighings. The purpose of automation, at least in part, is to remove human error. The high furnace performance demanded requires proper filling at all times.

In the face of increasing complexity, we must stand for simplicity and reliability. Which is the simpler and more foolproof, the punched card or tape system or the specially designed panel board with setup switches, dials and pushbuttons?

In the rebuilding of the stockhouse of an existing furnace we note the retention of the scale car as a spare unit. What is planned for spare equipment in a new installation?

John F. Meissner: The scale car is retained for standby use, because it is very easy to do so in almost any existing stockhouse. When one does something quite new, it is not a bad idea to retain a facility like that. As good as we expect the electrical and the mechanical system to be, it is all very new and may have a few "bugs" that must be worked out; and then it may be necessary to go back to the scale car operation for a time or two, before the system is perfected.

We prepared many time studies to explore the possibilities of this system. The operations can be performed automatically and with great speed, and they can be quickly repeated. At present, the scale car operator travels to a certain bin and manually operates the gates, and travels back. This goes along nicely for the first few hours, but after five or six hours, the man becomes weary and does not work fast enough to keep up with filling requirements. Power operation can keep on at the same pace and speed from morning until night.

If we could have as large as 350-cu ft skips for a new 30-ft blast furnace, we could nicely take care of the filling operation and have time to spare. We need not look for new ways, such as double skip hoists and find a way of dumping four skip buckets into one hopper at the top. This is a bit of a trick in itself because everything must converge into this one point which presents many difficulties, and this has not yet been solved.

Accuracy of scales and scale feeders is well along to a good solution. We are using electronic scales and will know more about them when they have been applied and are working. Whenever electronic scales have been used, they have generally given a good account of themselves.

The design of the electronic feeders and their physical arrangement will make it possible to take out a complete unit and slip another into its place, so any adjusting and tinkering can be done elsewhere to avoid operating delays.

With respect to controls, whether a panel of setup switches would be better than another kind of control, let us say punch cards or tape, is something we hardly know. Any one will give identical accuracy or versatility of operation, because the same type of static switching units and other control units are used in any case.

Charles M. Squarcy: Many of the excellent recommendations are too good to wait until "Manana." This is naturally not economically feasible in most plants already constructed. However, many an operator, if he would take a hard second look at his equipment, could possibly super-impose some of these new automatic devices with tremendous advantage.

An example of the above is Inland's No. 6 blast furnace. Constructed with a 25 ft-9 in. hearth diam, No. 6 furnace was designed to produce 1250 net tons per day. Today No. 6 furnace is equipped with high top pressure and moisture injection and is capable of producing in excess of 1700 tons per day with no alterations to the charging facilities.

The number of skip loads per day which is a reflection of the increased work load throughout the charging operation has been increased 25 per cent. To minimize this figure, the fill orders were changed and altered for efficient use of each skip trip; and still on many occasions a check of the fill rate is required to enable the stockhouse to "catch-up" with the furnace. Yet the operators must still depend greatly on proper filling and distribution for proper operation of the furnace. More is still to be expected of the present day equipment with plans to equip No. 6 and others with increased flux-sinter burdens, natural gas and oxygen enrichment.

Particularly in regard to construction of new equipment the paper involves a train of thought concerning automation which need not stop at the stockhouse level. If we are going to replace batch type loading with continuous flow, why not then all the way to the top of the furnace? Materials deposit themselves on the bells differently than they used to because we prepare them extensively. That means we should consider using belt conveyors for blast furnace charging (it is being done now successfully at Cockerill in Belgium). Also, attention should be given to the elimination of the bells and rotating tops. This would help seal the furnace and make high pressure operation easier—permitting higher pressures to reduce top maintenance.

Years ago fires were fought by the bucket brigade—batch type work, passed hand to hand. Now our firemen supply a continuous stream of effective fire control material. We hope designers can utilize the same principle of continuity of feed to our benefit.

Dr. Thomas M. Stout: In steelmaking operations, as well as many others, it is quite possible that you would get minimum cost *per ton* under conditions which also correspond to maximum production. Minimum unit cost might be a very reasonable sort of objective for a computer control system. The point is that if you are going to turn process operation over to a computer, you must be careful how its objective is stated so that the actions which it takes will be acceptable.

A computer might be applied in a conventional stockhouse with a scale car for collecting ore, limestone and other materials for delivery to the skips. However, it should be added that the computer is adaptable to

quite a variety of stockhouses. It would lend itself nicely to the control of weighing feeders, bins and other devices that have been described by the author.

J. Raymond Erbe: Our company is supplying the programming control for the blast furnace discussed in this paper. We concur with the author's suggestion that this might well be the subject of a future paper.

The type of static control used for this programming will be of the same order of complexity as that used for full automatic control of a blooming or slabbing mill, with complexity being defined as the number of basic logic functions required for the system. The stockhouse programming, however, is inherently more flexible than the slabbing mill control, which is reflected in the control, and means that failures in more places could be tolerated without serious process interruption. The reliability of this control is expected to be very high since it is all static and has no moving parts.

Some of the salient features of this control are:

1. Two basic methods of operation are provided—"automatic" and "manual." The latter by-passes the logic control entirely.

2. Several secondary methods of operation are available on the "automatic" cycle. These are:

a. The north and south coke systems can be switched "on" or "off" separately.

b. The entire coke system can be switched to "manual" operation while the remainder of the system continuous on "automatic" operation. In this case the coke would be fed manually from the emergency hoppers.

c. Either side of the coke system may be set on "emergency" whereby automatic operation is still continuous but coke is drawn from the emergency bins. This would by-pass the conveyor system.

d. The ore system may be cut out independently and ore fed from the scale car. This would be done, for instance if the pivot conveyor failed.

e. Either side of the ore system may be cut out if a collecting conveyor fails. The remaining side could continue on "automatic" with the rest of the system.

f. Manual by-pass of water addition is possible with remainder of the system remaining on "automatic."

g. A good many failures in the programmed setup can be by-passed while the remainder of the system continues to operate automatically. This may require some changes in the program but a complete shutdown or manual operation would be averted.

h. The recording typewriter can be shutoff and the control mill continue to operate. In this case a record of the charging and furnace operation would not be maintained.

i. The various individual ore and coke bins can be by-passed, if they are empty or disabled, and the system continues to operate automatically.

3. In switching the method of operation from "manual" to "automatic" one skip must always first be returned to the pit.

4. Absolute failure of some functions will stop the system completely. These are: the skip hoist drive, the large and small bell drives, d-c power failure, nonavailability of a scale car when forced to operate the flux system on "manual."

5. Absolute failure of other functions will not stop the system but will require complete "manual" operation. These are: a-c power failure to the static power supply, failure of the power supply itself, failure of the program advance logic, failure of the skip sequence logic.

W. F. Huntley: There is considerable incentive in making the change-over to the completely automatic materials handling system, for we all know what an improvement it has made in furnace operation to have automatic operation of the skip hoist, the distributor and the bells, as well as automatic coke weighing in a good many instances.

It is readily understandable why it is desirable to have the scale car as standby equipment in case of an emergency. However, if its presence is going to substantially prevent a more favorable design and layout of the automatic materials handling equipment, the scale car should be dispensed with. The plan for the scale mounted weigh hoppers to receive material from the conveyor belts is a good one. We wonder if the requirement of emergency scale car facilities is preventing its being used in some cases. If it is, would it not be preferable to eliminate the scale car emergency filling?

Eventually, we will be able to fill the furnace with a chemically balanced burden, but we must still bear in mind that the inertia of a blast furnace is something to be reckoned with and that the blast furnace operator will have to still apply his art with skill.

James E. Oram: The author has presented an informative discussion of the system his company has designed for automatic assembling and charging of blast furnace raw materials. Fully automatic charging is an important step in the evolution of blast furnace systems of the future, and in itself provides many benefits to blast furnace operators in the form of: (1) better control of furnace burdening, (2) reduced possibility for human error in charging.

Of perhaps even greater importance, to the steel industry, however, are the potential benefits of systems employing some of the techniques which the author has termed "future." The future is *now* for many of these techniques.

For example, it is *now* possible to "direct" burdening of the furnace with a general purpose digital computer which receives frequent, accurate raw materials analysis data from "on-line" x-ray emission analysis equipment.

Both the general purpose digital computer and the "on-line" x-ray analysis gage are a practical reality today.

With such a system, a chemically-balanced burden will be continually fed into the furnace. The result will be a more uniform, more predictable furnace operation, with consequent increases in production, reduction in cost, and improvements in product quality.

This same general purpose computer will serve as a valuable tool for monitoring the furnace operation and gaining knowledge of the process through acquisition of "time correlated" data and analysis of this data.

Finally, the computer will "direct" operation of the process in response to changing conditions on the furnace. To some, "computer direction" of the process may seem to lie in the distant future, and indeed, the ultimate process director system may be some time away. Nevertheless, initial steps in the evolution of the blast furnace "process-director-system" will be taken in the very near future. ▲

Progress in automatic mill control is so rapid that prophecies made in first part of paper become actualities before the last line is written.

New Techniques in Mill Control gives better hot strip

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IF good practices prevail in the steelmaking area, and proper ingot pouring, topping, cooling and soaking methods are employed, the percentage yield in top-quality, uniform slabs from the slabbing mill can be considerably higher than would be possible if these areas are not given adequate attention. This paper assumes that good practices have resulted in the production of economical, uniform slabs, and discusses the problems of rolling uniform hot bands from these slabs.

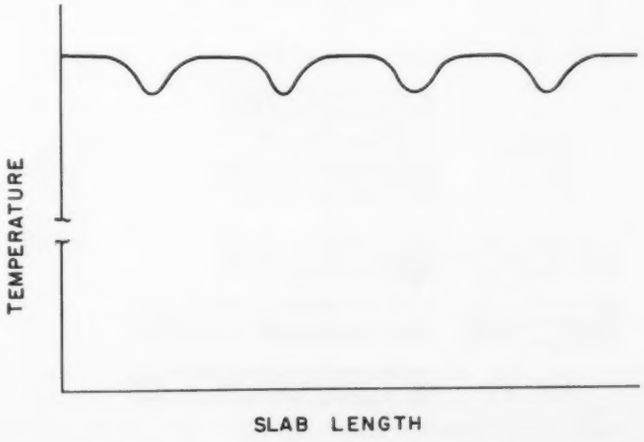
Although the metal-making and rolling processes ahead of the hot strip mill exert a definite influence on the product quality and accuracy, the hot strip mill is the first logical place where accurate controls may be installed to adequately control shape and profile of strip products. If hot bands of uniform gage are delivered to the cold mills, then the problem of delivering on-gage cold-rolled sheet or tinplate is almost eliminated.

A hot strip mill represents a huge investment in land, buildings, capital equipment, service charges and fixed labor expense. A typical hot strip mill may roll 2,000,000 or more tons per year, which in many steel mills represents the largest percentage of the total production. Assuming scrap and off-gage losses can be held to as low as one per cent there is still an annual loss of 20,000 tons of production valued at about $1,000,000. If as little as one per cent of the losses in the cold rolling and finishing areas can be chargeable to poor quality of hot bands an additional $1,500,000 loss can easily result. One can readily see that even a minor improvement in quality can result in substantial savings.

REHEAT FURNACES

Starting with our uniform slab, it is usually transferred to slab storage for scheduled charge into reheat furnaces. (Some producers are able to bypass the slab reheat furnaces and roll finished hot bands from ingot heat.) The slabs are supported in most furnaces by water-cooled skids, which prevent uniform heating of the slab and result in "cold" spots where the slab rested on the skids. Leaving the heating zone of the furnace the slab passes through a soaking zone where it slides

Figure 1 — Temperature profile of slab when leaving reheat furnace shows effect of skids.



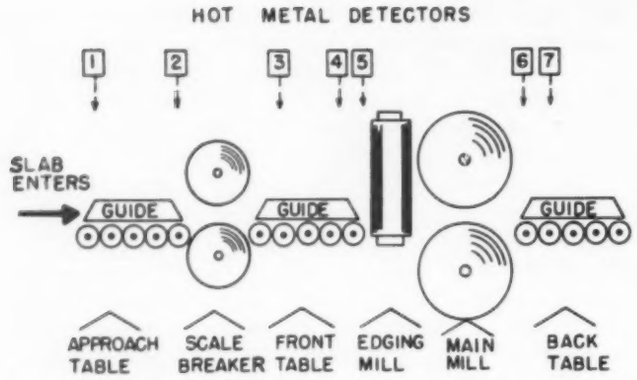


Figure 2 — Schematic diagram of automatic reversing roughing mill.

along stainless steel skids which are not cooled. If left there long enough, the temperature would equalize throughout the slab. It appears, however, that economics dictate a shorter time. As a consequence, the slab leaves the reheat furnace with a temperature profile as shown in Figure 1.

ROUGHING MILL

The slab is discharged from the reheat furnaces onto the mill tables and is ready to be rolled either in a continuous roughing train or by a reversing rougher with edger. In the roughing section the slab is reduced to about ¾ in. thickness and final width is maintained or established by the edger. Little can be done to control gage at this point as the slab is too thick for accurate meausrement by known means. However, much can be done, particularly with the reversing rougher, to insure that slabs of consistent thickness are delivered to the finishing mill.

AUTOMATIC REVERSING ROUGHER

Card programming of reversing mills has been described in recently published papers and typical operation will be only briefly discussed here.

The first step toward automatic control is the use of punched card preset screwdown control. While preset screwdown control has been quite common for many years, the important change is the use of a punched card for defining the program. Schedules can be changed rapidly, additional information for controlling other functions can be readily incorporated, and use can be made of existing business machinery for card punching, handling and accounting.

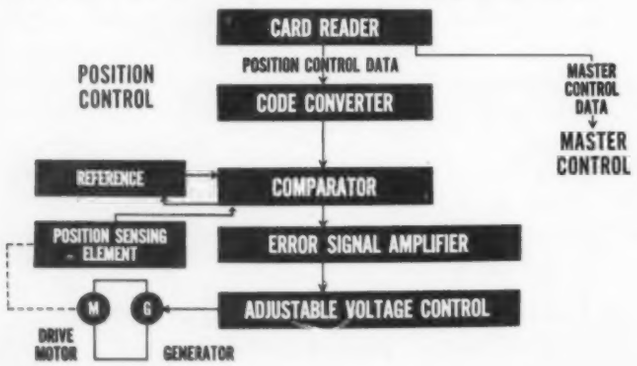
On a recently installed reversing roughing mill there was provided three modes of operation: manual, semi-automatic, and fully automatic. During manual operation, all functions are manual as they have been on previous mills. During semi-automatic operation, only mill speed and screw position are programmed. During fully automatic operation, all functions normally performed by the operator are done automatically.

If the equipment is operating in the automatic mode, the sequencing which controls the initiation of mill functions will stem from several hot-metal detectors as shown in Figure 2. As the slab approaches the mill, the first detector closes the scale breaker side guides to center the slab on the table. The second detector operates the scale breaker sprays and the third detector operates the mill sprays. Now the slab passes through the edger and mill. As the trailing end of the slab passes under the entry slowdown detector (No. 4) the mill slows down so as to deliver at a low speed. Final stop and reversal of the mill is initiated by the first detector on the delivery side (No. 6). For the remainder of the passes, the four detectors near the mill (No. 4, 5, 6 and 7) control slowdown and reversal until the schedule is complete.

Now look briefly at the screwdown positioning control, Figure 3. The card reader feeds desired screw position from punched card into the code converter, which selects the proper position reference which is then compared with the selsyn output. Any error between desired and actual roll opening is amplified and through the control drives the motor to the proper position. The screws move automatically to the proper setting for each succeeding pass in response to a signal from the hot metal detector which indicates that slab has just left mill.

The major advantage of automatic roughing mill programming in control of gage is the continuous delivery of a consistent product to the finishing train. Operator fatigue and individual rolling preferences are eliminated. Even though the operator has already rolled a hundred slabs today, and may have attended a party last night, the slab is delivered with accurate dimensions under the control of the punched card program.

Figure 3 — Block diagram shows card program control.



CROP SHEARS

Before entering the finishing mill, the slab passes through a crop shear, scalebreaker and high pressure descaling sprays. New electrical techniques can be of value here also. On many mills, a crop shear operator watches the slab, and if he judges that the poor shape of the front end may cause a cobble in the mill, he stops the slab, jogs it to the proper position, and crops the front end. He may also deem it necessary to crop the fish-tail trailing end of the slab on the fly. In either event, it takes mill and operator time to fulfill this function. There are two alternates to this operation: first, automatically crop front and tail edges of all slabs a preset amount and second, automatically crop only as much as necessary. The first alternate is fairly straightforward, requiring only that the mill entry table be operated at a constant speed while slab passes under

shear, and the use of a hot metal detector and adjustable timing relay to initiate the shear for both front and tail cropping. This alternate has eliminated a major cause of mill cobbling, but crops a certain length from the slab whether it is required or not.

The second alternate represents a more sophisticated approach which our company has built, tested and shipped, and is now installing in a mid-western steel mill. It is expected that savings in excess of $100,000 a year can be realized. Since this equipment will be the subject of a complete paper in the near future, only a brief description will be given. The equipment consists of a crop cut detector, which determines the optimum point on the slab to be sheared, and a control that position regulates the shear knives to the point selected so that the slab is actually sheared at this point.

FINISHING TRAINS

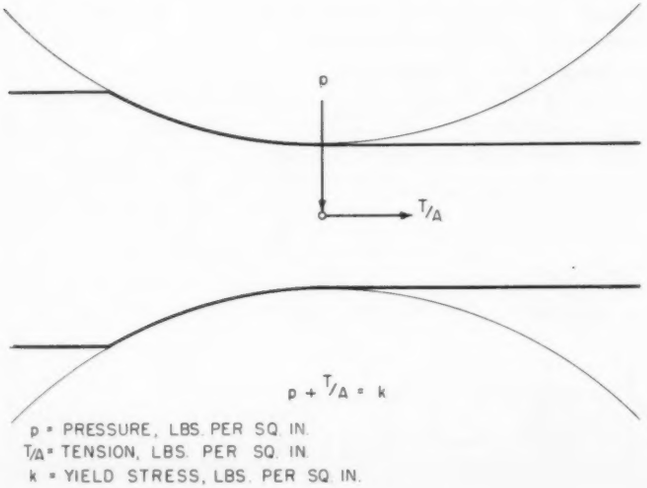
The slab is now ready to enter the finishing train. The opportunities for improving mill operation and product quality with resultant increased production of on-gage tonnage are enormous and provide a real incentive for automatically controlling gage.

AUTOMATIC GAGE CONTROL IN THE FINISHING MILL

The subject of automatic gage control for cold strip mills has been very well covered by many papers given before the AISE. One paper was presented covering "Methods of Control of Strip Dimensions on Hot Strip Mills," by R. A. Phillips (1958 Proceedings AISE, p 392). Only a brief coverage of the more important aspects will be covered here.

Principles—Discussion of the subject of gage control requires a brief review of the physics of the rolling process. Strip is made to flow plastically as it passes between the work rolls, Figure 4. If in addition tension is applied on either side of the roll gap, the roll pressure required will decrease since plastic flow theory states that the vertical compressive stress plus the longitudinal tensile stress must equal the yield stress at every point in the roll gap. The rolls and the mill housing act

Figure 4 — Relationship between roll pressure and strip tension at the work rolls. As tension is increased, pressure is reduced.



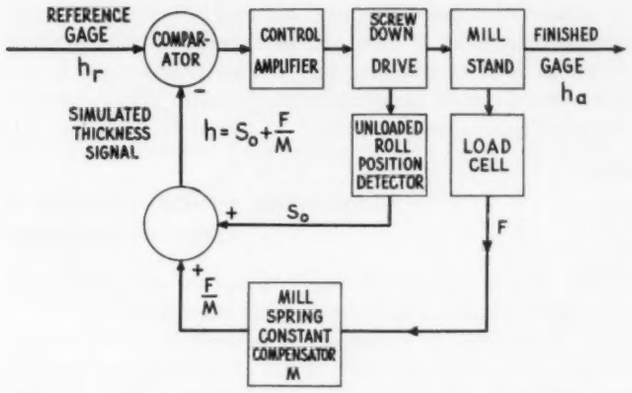


Figure 5 — This gagemeter system uses mill spring as measure of load.

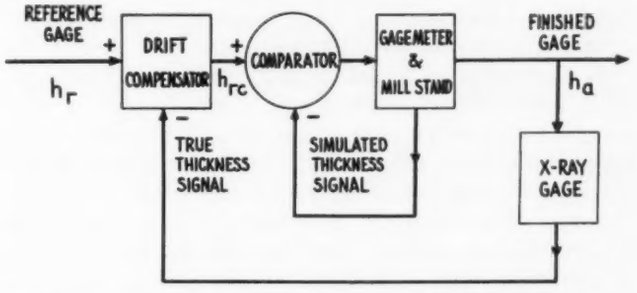


Figure 6 — Gagemeter system has drift compensator to compensate for such factors as temperature.

like a large spring and tests show that the combination obeys Hooke's law in the working range; that is, there is a linear relationship between the change in work roll force and change in roll opening. Therefore, when tension is applied to the strip at either the entry or exit side of the roll gap, the roll pressure decreases and the work rolls move closer together until a new point of equilibrium is reached. The delivered thickness can be decreased by increasing incoming or outgoing tensions, or by increasing roll pressure. Thus, gage controlling means must use one or both of these methods on one or more stands of the mill.

Before one can control gage one must be able to measure it and detect how it is varying. Futhermore, one must do this almost instantaneously to be able to do anything to the mill to correct off-gage material.

Practically, there are two basic means of gaging the thickness of the metal in a hot strip mill—radiation gages and the use of the mill stand itself as a gage. The latter method utilizes the fact that the mill stand and rolls act as a large spring. If one knows the separation between rolls before metal enters the rolls (see Figure 5) and adds the separation caused by springing apart of the loaded rolls, an indication of strip thickness is obtained. Roll separating force may be readily measured by use of load cells installed between the mill screws and the backup roll chocks. Dividing by the spring constant of the mill (expressed in lb per in. of deflection) gives stressed roll separation. This method of thickness measurement is known as a "gagemeter" and since it measures right at the roll bite, it gives an instantaneous indication of thickness change. Unfortunately, the gagemeter alone does not recognize certain factors such as changes in temperature of mill rolls and mill housing. See Figure 6. However, it may be readily recalibrated, continuously,

by means of a radiation gage located after the last mill stand. By use of a load cell as a roll separating force detector, and controlling screwdown position to maintain constant roll opening, a truly automatic gage control system can be obtained.

FACTORS WHICH INFLUENCE STRIP DIMENSIONS

The major causes of gage variation out of the hot strip finishing mill result because of the following:

1. *Variations in incoming temperature.* As discussed earlier, water-cooled skids in the reheat furnace lead to cold spots in the bar. With modifications to the furnace, these cold spots can conceivably be minimized. A second temperature variation occurs due to the elapsed time that bar lies on finishing mill entry table after the head end has entered the mill. Thus there is usually a sizable temperature decrease from head to tail.

2. *Variations in incoming gage.* There are two principal causes of strip thickness variation out of the roughing mill with a reversing rougher. The mean thickness from strip to strip will vary if the roll openings for the successive passes are not set consistently. However, the use of numerically programmed roll positioning equipment and punched card storage makes it possible to minimize this type of strip thickness variation. A second cause is the result of the cold spots from the reheat furnace as the slab passes through the roughing mill.

3. *Lack of tension at the front and tail end of the strip.* The loss of tension when the tail of the strip leaves the first stand and subsequent stands causes gage to run heavy at the tail end. Similarly, the front end from stand 1 to stand 2, etc., is rolled without tension causing gage to run heavy at the front end. Heavy gage at the front end of the strip is far less of a problem than at the tail end because the temperature is higher. With speed regulators, mill can be accurately preset so that front of strip will be rolled with essentially no interstand tension conditions. As the strip is being rolled, it enters the mill at lower temperature and tension tends to build up. Obviously, it is desirable to operate entry tables at the same speed that strip will enter the mill so that the cooling effect of the descaling spray will be uniform.

CORRECTION OF INCOMING EFFECTS

In his paper, R. A. Phillips has demonstrated that it can be expected that the requirements for a regulating system to compensate for strip temperature variations introduced into the finishing train will be more than adequate to compensate for the strip thickness variations introduced.

Basically, there are but two ways to minimize the effect on strip dimensions caused by temperature variations. One choice is to eliminate the cause by reducing to a small value these variations from strip to strip, and within a strip. The second choice is to use thickness regulators acting to change roll pressure and/or strip tension. This eliminates the effect. We, as electrical manufacturers, have confined our efforts to the second approach.

Temperature variations appear to the mill as hardness variations. It can be shown that if the mill were perfectly stiff these hardness variations would produce no thickness variations. What is more important is the fact that no interstand tension variations will be produced by the perfectly stiff mill. Such a mill then should roll strip of uniform thickness and uniform width.

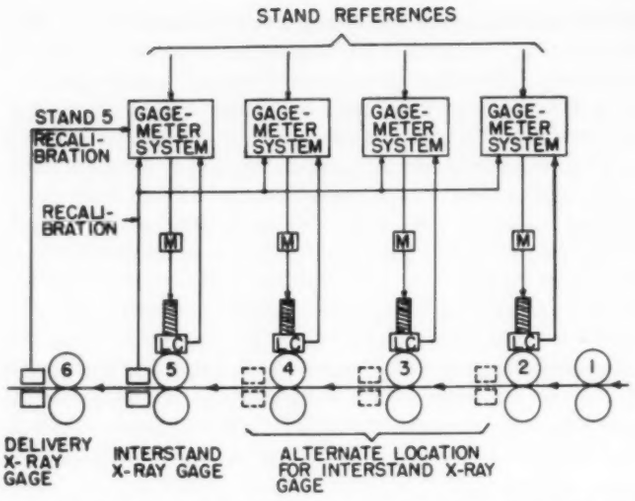


Figure 7 — A preferred automatic gage control system has four gagemeter-screw systems.

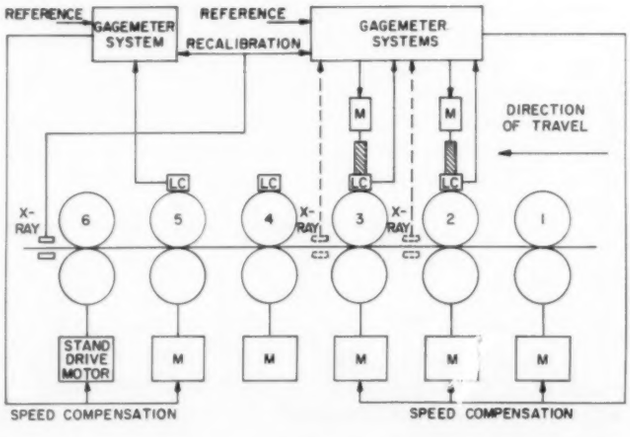
This question then arises. Can a perfectly stiff mill be realized in practice? By definition, a perfectly stiff stand is one in which a change in roll force produces no change in work roll separation. From a mechanical design standpoint, such a mill is impractical, but considering the mill as an electromechanical system, this concept is possible. A regulator acting quickly to change roll pressure of a stand to hold constant thickness delivered from that stand approaches this definition.

If less than six of the stands are made stiff in this manner, some of the interstand tensions will vary. These tension variations can be minimized by quickly varying the appropriate stand speeds in addition. It should also be remembered that a change in interstand tension can be used to obtain changes in roll pressure.

AUTOMATIC GAGE CONTROL SYSTEM

The gagemeter system, operating through load cells, is a closed loop regulating system which continuously

Figure 8 — Schematic diagram shows a less expensive automatic gage control system.



regulates gage at the point of roll contact. There are two variations of the gagemeter system—one operating through screwdown movement, and the other operating through changing interstand tension ahead of and after the point of work roll contact by changing the appropriate stand speeds. The first method is identified as gagemeter-screw (for screwdown control) and the second as gagemeter-tension (for tension control).

Of the several possible approaches to automatic gage control systems for a hot strip mill, the first recommendation is shown in Figure 7. This system, which produces the most uniform thickness throughout the entire length of strip incorporates four gagemeter-screw systems on Stands 2, 3, 4 and 5. This system does not cause appreciable change in interstand tensions and therefore strip width is not affected. Cold (and therefore hard) spots in the slab are rolled out through the action of successive regulators. Tail-end gage build-up due to temperature rundown and loss of tail-end tension that occurs on a conventional mill are minimized. An x-ray gage is used after the last stand to monitor the system and to record final strip thickness.

A second recommendation, shown in Figure 8, is less expensive and will do an excellent job. This includes a gagemeter-screw system on Stands 2 and 3 and a gagemeter-tension system on Stand 5. Large gage variations are reduced in the gagemeter-screw stands so that only small vernier changes need be made by varying tensions between Stands 4 and 5 and between 5 and 6 using the Stand 5 gagemeter-tension system. Tension variations will not affect strip width beyond normal commercial tolerances. The combination gagemeter-screw and gagemeter-tension system cannot control thickness at extreme ends to the degree that the all gagemeter-screw system does. Speed regulators are mandatory to provide the precise and rapid control of stand speed required by the tension control.

Continuously operating interstand radiation gages are not required for either of the recommended systems described above, but they are strongly recommended to verify proper operation of the gagemeter during installation and for occasional use when maintenance on the system may be required.

Screwdown drives should be driven through a double-voltage adjustable-voltage system. In many cases the gear ratio should be decreased and perhaps horsepower increased so that speed of correction may be increased.

STEPS TOWARD THE AUTOMATIC FINISHING MILL

Since the investment required to reach the ultimate in quality production and automation is considerable, in spite of immediate benefits received, a logical approach may be by progressive steps. Each step in itself becomes a major improvement, and in turn is the foundation for the next step. The ideal sequence is:

1. Addition of speed regulators.
2. Automatic gage control.
3. Data logging (measurement of mill performance).
4. Programming.

SPEED REGULATORS

To achieve the immediate objective, the production of on-gage strip by means of automatic gage control,

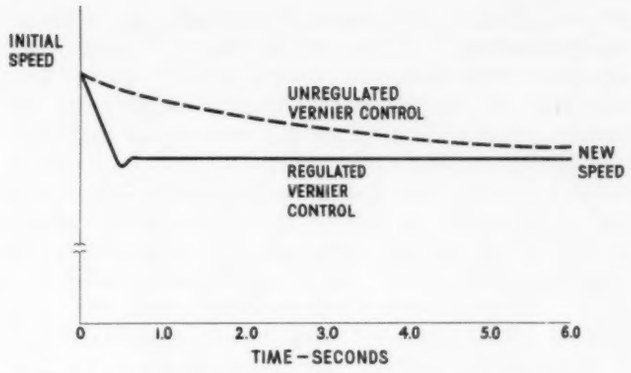


Figure 9 — Rolling mill response to vernier change.

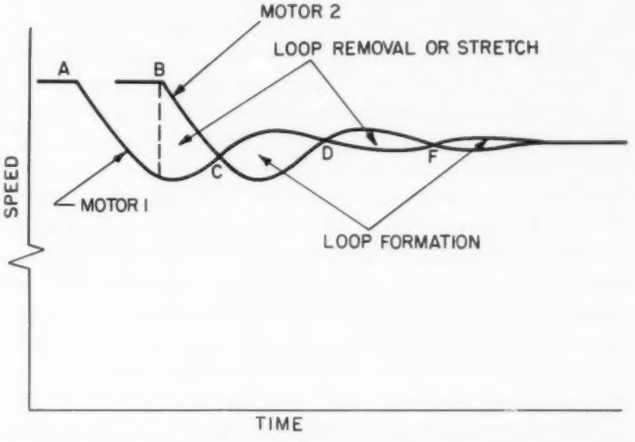


Figure 10 — Looping and stretching are caused by transient speed mismatch.

it is essential that there be fast and accurate control of stand speeds. Prior to the addition of automatic gage control, many direct benefits are achieved by the addition of speed regulating systems.

The principal benefits to be derived from the addition of speed regulators are:

1. *Increased production by reducing mill setup time.* The no-load speeds of the stands can be preset to the rolling speed desired. No longer must the operator estimate the load speed drop and manually compensate for this speed difference. The speed regulators will maintain essentially constant speed under all steady state load conditions. The regulators, with their high speed of response, allow the operator to change stand speeds more rapidly for different rolling schedules.

2. *Reduction in number of cobbles (Figure 9).* The fast speed of response of the manual vernier controls enables the operator to make fast corrections. One hot strip mill equipped with this improved control system estimated that the average number of cobbles was reduced 27 per cent and the average time lost due to cobbles was reduced 35 per cent.

3. *Reduction in magnitude and duration of transient speed changes due to load (Figure 10).* All motors are subject to impact speed drops. The transient characteristics vary with the amount of field weakening. Regardless of the field strength, the transient characteristics can be altered and considerably improved with speed regulators. As the steel enters successive stands of the mill, the impact speed drop upsets the speed relationship between adjacent stands and causes looping

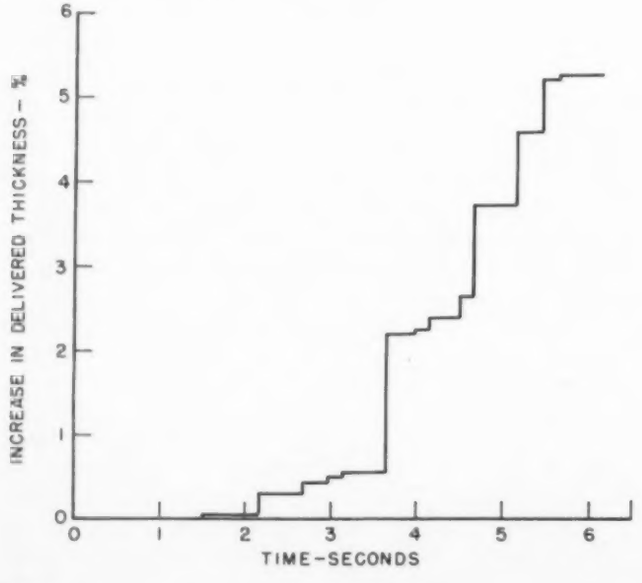
or stretching of the metal. Strip gage and width are directly affected by this action. Speed regulators will decrease somewhat the actual impact speed drop, minimize the speed oscillations, and improve the recovery characteristics, thus improving gage and width deviations due to tension variations.

4. *Adjustable speed droop.* Regulators may be set to hold any desired speed droop with load. This may be adjustable by the operator from say 0 to 4 per cent at full load. This control permits mill adjustment from a very "stiff" mill, zero droop, for rolling strip, to a "soft" mill considered desirable for rolling heavier products such as skelp or plate.

If the droop setting equals the impact speed drop, the motor impact speed drop characteristic appears to be critically damped and high accelerating currents to re-accelerate motor to the no-load speed are not required, as would be the case with zero droop setting.

5. *Tail end compensation.* Since there is some interstand tension during rolling, even with loopers, there is a problem created when the strip leaves the mill. When strip leaves the first stand, tension is lost between it and the second stand. Since there is less back tension at stand 2, the strip will try to speed up with respect to the rolls. The exit velocity of the second stand will thus tend to increase with respect to the entry velocity of the third and tension between them will decrease. The result is that delivered thickness from each stand will increase. This trend continues, diminished, down the mill. As the strip leaves each stand successively, the phenomenon repeats between remaining stands with cumulative results. For calculation purposes, it was assumed that the interstand tensions prior to the strip leaving the mill were all 4000 psi. Figure 11 shows the calculated thickness profile of the tail end of the strip as delivered from the last finishing stand. Time zero is taken at the instant the strip leaves the first stand. It is probable, in actual practice, that the mill is set up with somewhat lower tensions than the above between the early stands and somewhat greater tensions between the later stands. The resultant curve would start more slowly and rise more rapidly as strip leaves the later stands. With speed regulators, some compensation can be made for this effect by slowing down the second stand as soon as strip leaves the first. The increase in tension between stands 2 and 3 compensates for the loss of stand 1-2 tension and helps to correct for the heavier gage leaving stand 2, and so on down through the mill. Without speed regulators this precise and rapid reduction in speed could not be made.

Figure 11 — Calculated finish gage profile of tail end of strip from hot strip finishing mill.



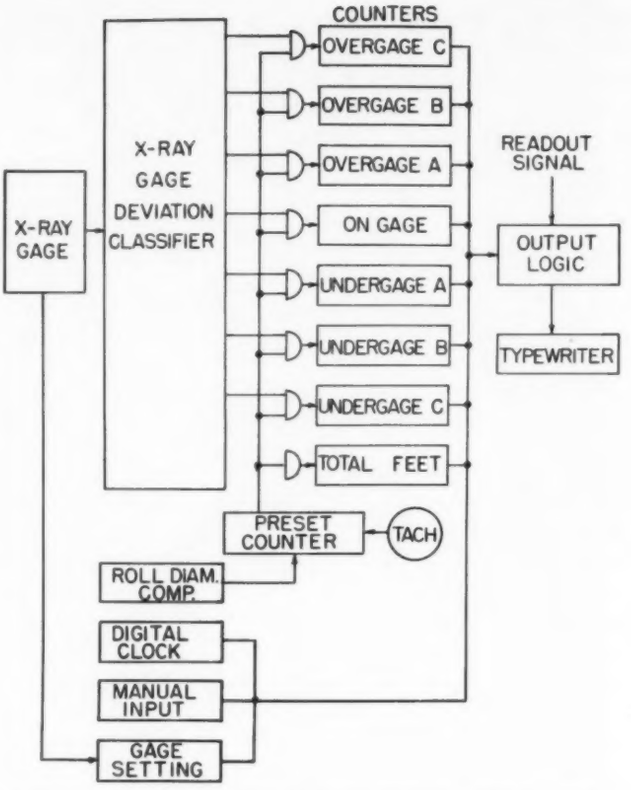


Figure 12 — Block diagram shows gage logging system.

DATA LOGGING AND PROCESSING

Data logging and processing is a broad subject. In its simplest form on a hot strip mill it would consist of a numerical or digital gage logger. This is a tool for measurement and quality control. As such, it is difficult to say whether this is needed before, after, or with the addition of speed regulators and automatic gage control. It would be valuable to have readable, understandable records of strip thickness variations before such changes were made. It would be even more valuable to be able to monitor and analyze equipment performance as additional controls are added.

The gage logging system accumulates the total number of feet in each tolerance band of undergage and overgage. A record of the number of feet of on-gage and the number of feet of off-gage material in each tolerance band, as well as the total number of feet in the coil, is printed out when the coil is completed. A system schematic drawing is shown in Figure 12.

The pulse tachometer, driven from one of the mill rolls and compensated for roll diameter gives one or more pulses per foot length of strip. The x-ray gage continuously measures the thickness of the strip and

gives an indication proportional to thickness. This signal is divided into tolerance bands by the gage classifier. The output of the classifier is a switch closure corresponding to the tolerance band in which the thickness of the strip lies.

Thus, as thickness of strip varies, the total number of feet is accumulated, as well as the total number of feet in each off-gage band. On completion of coil this information is printed out for a permanent record. In addition, the gage logger permits recording of coil identification, turn, crew, time and x-ray gage setting. A modification permits recording of strip thickness profile on paper tape.

One of the most attractive features of the gage logger is its adaptability and portability. It can be used just as advantageously on tandem cold strip mills as it can on hot strip mills.

Since data logging is a relatively new production technique in the steel industry, let us look at some of the major direct benefits to be obtained from such a system.

1. Speed in obtaining necessary information.
2. Accurate information free of human error.
3. A complete record of product quality of each coil in typewritten, punched tape or business card form.
4. Greatly decreased labor in observing, transcribing and correlating data as compared with that required with strip charts and direct reading instruments.
5. Automatic correlation of related data such as strip width, strip gage, temperature and time; and correlation of data with reference to particular slabs, plates and ingots.
6. Compatibility of data logger output with business machines and computers.
7. Improvement in yield and quality of product as a direct result of being able to obtain accurate process information in immediately available, usable and understandable form.

Requirements vary widely and we have proposed or furnished data processing equipment to the steel industry varying in complexity from simple gage loggers to overall data transmission systems and simple process computers. In a hot strip mill, production men may need a more elaborate accumulation of data, including strip width, width deviation in tolerance bands, coil weight, strip composition, temperature, etc. They may also need an all-inclusive system which accumulates pertinent data on each slab from the open hearth furnaces to the sheared tinplate. This can also be done either in process steps, each compatible with the overall system, or in one giant step. Many steel mills are purchasing and installing data accumulation systems on the most critical processes, generally working toward an overall centralized system in the future.

PROGRAMMED MILL

The slab has now been rolled on-gage and its identification, dimensions (and deviations), weight, composition, crew, and time have been neatly typed, and punched in tape. The new electrical techniques have controlled the hot strip mill for accurate and economical product. But having gone this far, would it not be nice to insert a punched card in a reader, press a button, and have all mill screws run to the proper setting and all stand speeds adjust themselves for a particular schedule? Or better yet, push three decade buttons calling for a certain schedule by number. The schedule number, screw openings and stand speeds are visually displayed, called out of a simple, reliable, rotating drum storage element. Pressing a button sets the mill up in seconds. Fantastic? Not at all! We have already built and installed a simpler scheme using decade pushbuttons to set each stand screw opening. We are now proposing a complete punched card programming system which will permit very rapid set up of mill screws and stand speeds. Of course, the screwdown position regulators have already been designed for operation from digital commands. The digital speed regulator will be superimposed on the existing analog speed regulator as a digital overloop. Manual overriding control will still be retained to permit the operator to make corrections in screws or speeds as required by the product or by rolling conditions.

The problems of this system have been carefully considered with regard to mill temperature change or roll wear and can be effectively accounted for. Suppose, for example, the mill equipment is set up with a cold mill and new rolls, and the first card is inserted and read. As the steel is rolled causing mill heating and wear, the operator will naturally make manual adjustments to stand speeds or screw positions as required to produce the proper product. The automatic equipment will continuously observe such manual corrections, so when the next card is read the same corrections will be applied to that card. The cards may also program scalebreaker screws and speed, sideguard opening, and reference for automatic gage control.

The rapid and accurate mill setup permitted by mill program control will eliminate operator errors, save valuable time in changing set up for new schedules, and enable the various rollers to follow a uniform and optimum rolling practice. This should permit maximum efficient utilization of the mill, and in conjunction with automatic gage control, produce maximum on-gage tonnage.

CLOSING THE LOOP

This paper has discussed the step-by-step approach to automatic gage control and the many benefits that may be enjoyed at each step. Reversing roughing mill programming results in consistent slabs to the finishing train; automatic crop shear cut control minimizes cobbles and reduces scrap loss; speed regulators save mill setup time, reduce number of cobbles, and permit tail end gage compensation; automatic gage control produces maximum on-gage strip; and the gage logger proves it.

There is just one more step to take to the completely automatic mill—closing the loop. For the immediate future, this is purely speculative, but studies are being made that will eventually lead to the use of a computer to observe mill speed, draft, and loading, and in accordance with proper mathematical relationships of the rolling process will calculate the proper corrections required and reprogram the mill to deliver the desired product.

Postscript: The authors are somewhat shaken by the prophetic statement made regarding the future closing of the loop. Since this paper was delivered great strides toward automation of hot strip mills have been taken, including the development of on-line process computers for setting and controlling the mill automatically for accurate and economical product.

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Discussion

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J. W. Brinks: As you would conclude from this paper, the steel companies and the electrical manufacturers have spent a great deal of time and money in studying rolling mill operation and designing control equipment with the primary aim of obtaining a higher yield of top quality product. One of the areas which has received much attention has been the programming of mill operation.

Since, to my knowledge, the local area steel plants do not have any programmed mills in operation, it would be of interest to supplement the authors' work by giving some specific examples of the various types of mills to which programming has been applied.

Our company has either in operation, or in the process of design, programmed control for the following mills:

a. 44-in. hot strip reversing rougher. The main rolls are driven by a 6000-hp twin-motor drive, and each of the edger rolls is driven by a 375-hp motor. Card programmed functions include mill screwdown setting from 0 to 14 in. in $\frac{1}{32}$-in. increments, edger adjustment opening 6 to 44 in. in $\frac{1}{16}$-in. increments, mill speed, and edger speed with draft compensation. This mill has been in operation for more than one year.

b. 52-in. hot strip reversing rougher. The main mill rolls are driven by a 5000-hp single-armature motor, and the mill is programmed for nine passes controlling screwdown opening only. It is necessary for the operator to manually reverse the mill and to initiate the programmed screwdown setting for each pass. This is the simplest type of programming. This programming system has been in operation for several months.

c. 160-in. reversing plate mill for rolling aluminum. The main drive is a 7000-hp twin-motor drive, 30/60 rpm. The programming on this mill controls only the main roll opening and the maximum mill speed for any one pass. This mill has been in operation about nine months.

d. Two-high reversing blooming mill. This mill is driven by a 12,000-hp, 40/80-rpm twin-motor. The programmed control includes automatic control of the screws, right and left manipulator, manipulator fingers, draft compensation, mill tables and start, stop, and reverse mill at any one of three programmed entry speeds and one of three accelerating rates for a maximum of 29 passes and for tandem rolling. This programmed control has been in operation for about three months' time.

e. 45 by 90-in. universal slabbing mill. The main roll drive is a 12,000-hp, twin double-armature motor, and the edger drive is a 4000-hp double-armature motor. The programmed control covers completely automatic operation.

This includes the start, stop and the reverse of the horizontal and vertical main drives, horizontal screwdown and vertical edger adjustment, manipulator and finger control, draft compensation, and mill table control. It can be programmed also to control a slab turn or a 180-degree turn and can provide for tandem rolling. The mill is programmed for one to 19 passes.

f. Reversing bar mill for research laboratory. The mill is programmed for 11 passes, screwdowns only.

g. Reversing roughing hot mill for Japan.

The above list of seven mills, to which the authors could add other mills, indicates that programming of reversing hot mills is no longer considered as experimental but is regarded as a necessary step in order to keep product quality at a maximum and operating costs at a minimum.

It is certainly safe to say that in the not too distant future other types of mills will be successfully programmed, and possibly even computer controlled.

Do the authors anticipate any particular problems in using the gagemeter system which they described from rapid variations which might be introduced in roll pressure due to nonconcentric backup rolls or work rolls?

It would appear that if such high frequency variations due to this or some other cause which does not directly result from strip thickness variations that

filtering circuits would have to be included to damp out these variations. To filter out signals caused by roll eccentricity effects would have the effect of increasing the gage control system response beyond the transport delays inherent with radiation gage systems.

R. J. Moran: The programming of reversing hot mills has come a long way in the last few years and there is ample evidence of the success of these installations. Automatic gage control and programming for hot strip mill finishing trains is relatively new, there being only one mill now in operation with automatic gage control. This mill also has a limited programming control through which the operator can manually preset screwdown settings.

The problem of nonconcentric rolls is a mechanical one which can best be overcome by good roll grinding practice. The advantages of measuring gage instantaneously right at the mill stand, rather than with an interstand x-ray gage, will make it worthwhile to improve the roll grinding operation, which will improve the product as well as eliminate distortion in the signal to the regulators.

L. Trewartha: The average mill has a variation in gage up to ten points. How much can you correct on that and how close to uniform can you make it?

R. J. Moran: With the system described in the paper, which is a minimum system, two gage meters controlling screws and one working on speed, a variation of plus or minus two mils can be accomplished for most of the strip. Extreme ends may exceed that.

Now, it is difficult to guarantee something like that because it depends upon how fast the incoming gage varies, furnace practices, and also depends in an existing mill on how much horsepower you have and how fast the screws will respond.

One of the limiting factors is the variation of gage with time and how fast we can get to work at it.

B. L. Rix: Does your width control act in the same manner as your gage control, in other words, do you use a load cell type edger control for width?

R. J. Moran: The gage control system cannot do anything about width in the finishing mill, that is, there are no edgers in the finishing mill. We can affect width, of course, if we use too much tension, but it is all in the neck-down direction. It is important to set up the system so that excessive tensions do not occur.

B. L. Rix: Would you control your width strictly with tension?

R. J. Moran: It is not exactly width control. We have to take the width delivered by the roughing mill. Since we use tension between Stands 5 and 6 and 4 and 5 as a vernier control of thickness, we can and do affect the width to some extent. However, we expect, and experience has shown, that if one does a good job with the screwdown controls at Stands 2 and 3, then the tension control in the later stands will not cause excessive width variations.

B. L. Rix: How do you insure that the width out of the roughing train is as close to desired width entering the finishing train as possible, or is that strictly the skill of the roller?

R. J. Moran: It is a matter of mill setup. Edger opening could be programmed of course, and has been on several reversing roughing mills. It can be done on edgers of continuous roughing trains too. That is the best way to assure yourself of a consistent width.

Walter Merry: Would putting fresh rolls, cold rolls in any position have any effect on the gage?

R. J. Moran: The operator, when he adjusted the roll opening for that stand, would have to make allowance for the difference in the roll diameter.

Walter Merry: What about the temperature of the rolls?

R. J. Moran: If he should put a new set of rolls into the stand, say Stand 2, on which there is a gage meter system controlling screws, then the first thing that he should do when he puts in the new rolls is to zero that stand. That gives the system the correct starting point. The use of the x-ray gage after the last stand would monitor this operation, and as the rolls expanded with increased temperature causing the roll opening to decrease, the x-ray gage would correct the initial setting of the gage meter control system to compensate for the increased roll diameter.

Walter Merry: Would that automatically compensate for it? Would you not have to have a manual adjustment there?

R. J. Moran: You would not have to have a manual adjustment. The thing you are really interested in, of course, is the gage out of Stand 6. When the new rolls are put in, if the operator saw the x-ray gage after Stand 6 indicating light gage, then he could manually make a correction in the control at Stand 2. However the control would be arranged so that a signal from the Stand 6 x-ray gage will automatically recalibrate the Stand 2 control.

Walter Merry: Would that not show up on all your succeeding stands from the new roll on?

R. J. Moran: Yes. The gage meter system does really what you tell it to do. If you want to hold 400 mils out of Stand 2 and you tell it to do that, it will hold 400 mils. However, suppose conditions change as you have suggested. It may go down to 350, so that you may find it necessary to reset the gage meter system reference. Unless you have an inter-stand gage, you will not know that Stand 2 is delivering at 350, but you will know by the gage after Stand 6 that you are delivering too thin so you must go back and re-set the Stand 2 system. This can be done either manually or automatically. The important thing to note is that an x-ray gage after Stand 2 is not required for continuous operation, but is most useful in making original adjustments at installation. If, after a year or so of operation, maintenance is required, then the x-ray gage is invaluable at that time for readjusting the system gains.

Walter Merry: Suppose out of your six finishing mills you would have three worn rolls so that you would have to put every other roll in, what would happen to your gage then?

R. J. Moran: It would have an effect on finished gage. But, if the finished gage either increases or decreases beyond what you want to hold, you can tell the gage meter systems on Stands 2 and 3 to make a correction, and that will compensate for what is going on in the rest of the mill.

You might be taking too much reduction at Stand 2, or 3, or you might be building up due to this roll condition in another stand. You do not need an absolute value of thickness out of any particular gagemeter

Stand 2. If you control the thickness at Stand 2, or 3, no matter what value to get what you want out of 6, you are accomplishing the purpose.

H. L. Klinker: What provision is made where you have two motor drives on your screwdown with a magnetic clutch between them to keep the mills level?

R. J. Moran: The gage meter system would work with the clutch closed and drive both motors at the same time.

Merle E. Ralph: That does not always work out. Suppose your mill gets out of plumb or out of level. How are you going to get it back? Is there any provision made to get it back?

R. J. Moran: The operator will always be able to take over from the automatic gage control, and he would have to go to manual operation to level the mill. After he had leveled the mill, he would go back on automatic operation and the gage control equipment would go back into operation.

H. N. Snively: As Mr. Moran pointed out, the screwdown clutch is normally engaged. If it is necessary to level the mill during operation of automatic gage control, the operator would jog one screw up or down. This would disconnect screwdown control from the automatic gage control. When the jog switch was released, the clutch re-engages, and control returns to automatic. If the average roll opening has changed, the action of the gage meter would correct the roll opening to deliver the same thickness from the stand as before the leveling action took place.

H. L. Klinker: Is there not considerable trouble with the magnetic clutches slipping, getting out of level?

H. N. Snively: Apparently this has not been a problem at installations with which we are familiar. Normally clutch torque is several times the torque rating of the motor. Thus any differential torque the clutch is subjected to is small compared to its rating.

H. L. Klinker: Is it not just the other way, the clutch just takes care of small physical differences in the drive?

H. N. Snively: If the torque of the clutch is exceeded, it will slip but this torque is generally well above the rated torque of the motor by several hundred per cent, and the differential torque transmitted between the two motors should be quite small on a well machined mill.

H. L. Klinker: If the mill got out of level is there any way to correct it?

H. N. Snively: With load cells properly installed on a mill, it should be possible to detect differential screw pressure and automatically jog the proper screw to balance screw loading. We are not certain this would be desirable; however, it is always possible to level the mill manually during rolling.

C. A. Bauman Jr.: What happens if you have a bar which is cold on one side? What is the effect on the load cell? Do they integrate for an average adjustment?

R. J. Moran: There is a load cell under each screw, and their signals are averaged and put into the gage control regulator.

H. N. Snively: Actually on the mill that we are speaking of there is a differential monitor that reads the difference between the load cell readings, so that this in itself is a very quick indication of mill being out of level or, as you put it, perhaps one side of the band being cooler than the other. The load cell in this respect is a powerful tool in indicating mill level and almost anticipating it. ▲

Revised and rearranged collection of articles which appeared in the Iron and Steel Engineer between 1943 and 1950 . . . a book for rolling mill men and for anyone interested in rolling mills and roll design . . . written from a practical viewpoint by one who has had considerable experience in the art of roll design.

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Automatic Control Systems for Gas Mixing Stations

by J. K. SAZAVSKY, Chief Application Engineer, GPE Controls, Inc., Chicago, Ill.

Control systems are available for practically any requirements of gas mixing stations.

THE purpose of the gas mixing station is to provide a gaseous fuel that is used either as a stand-by fuel or as a universal fuel. A typical gas mixing station consists of piping that brings in the fuels to be mixed, mixing chamber and an outlet line. If air is used for dilution of a rich gas, either an air blower or an air compressor is a part of the gas mixing station. The automatic control systems include the necessary safety circuits, sometimes combined with automatic startup and shutdown sequence, and the volumetric, calorific and pressure controls. Flow control valves, pressure control valves, automatic shutoff valves and metering orifices are part of the automatic control systems. The performance requirements and complexity of the gas mixing stations have increased over the years. Control systems have been designed for gas mixing stations that provide mixed gas with uniform heating value per cu ft, uniform specific gravity, uniform combustion air requirement or uniform flame characteristics. If proper fuels are available in unlimited quantity, two, three or all four of these characteristics can be satisfied at the same time.

The operation of gas mixing stations and of the automatic control systems can be best explained by describing a few typical installations.

Figure 1 shows schematically a gas mixing station designed to supplement available natural gas with a mixture of propane gas and air. The gas mixing station consists of a gas mixer, a propane line, an air line and a motor driven constant volume blower. The outlet of the gas mixer is connected to the natural gas line.

The control system is hydraulic and consists of four regulators, namely, natural gas flow regulator, propane gas pressure regulator, propane gas/air ratio regulator and air pressure regulator. Each regulator operates a control valve equipped with a double acting hydraulic cylinder. Flow metering orifices and pressure taps are provided in each line.

Safety features include a check valve in the air line, a pressure switch in the propane gas line upstream of the control valve, a pressure switch in the air blower discharge line and a pressure switch in the control oil supply line. The function of the air line check valve is self explanatory. The pressure switch in the air blower discharge closes both the propane gas and the air control valves any time the air blower is off. The pressure switch in the propane line stops the blower any time the pressure drops below the set minimum. The pressure switch in the control oil supply line sounds an alarm when the oil supply fails. At the same time the control valves are automatically blocked in their last position by means of spring actuated blocking valves installed in the hydraulic lines to the control cylinders.

The natural gas flow regulator maintains a constant flow of natural gas regardless of the plant demand. The flow is set at a rate lower than the lowest plant demand. The changes in gas demand are compensated by propane gas regulator. This regulator measures the pressure in the line leading to the plant and regulates the propane gas flow to maintain this pressure constant. The propane gas/air ratio regulator proportions the air flow to the propane gas flow to provide a mixture with heating value per cu ft equivalent to that of the natural gas. The ratio of the air to propane gas is manually adjustable to allow compensation for changes in the heating value of the propane gas.

The air pressure regulator controls a bleed valve at the discharge side of the positive displacement blower. It maintains a constant air pressure upstream of the air flow control valve by discharging to atmosphere the excess air.

The startup and shutdown of the station is manual.

Remote manual operation of the control valves is provided for this purpose. All control valves are provided with direct mechanical actuators for emergency operation.

Figure 2 is a schematic diagram of a gas mixing station that supplements a mixture of coke oven and blast furnace gases with a mixture of natural gas and air. The heating value of coke oven and blast furnace gas mixtures is maintained constant by other controls.

The natural gas and air mixing station consists of a gas mixer, a natural gas line and a pair of motor driven centrifugal air blowers. The outlet of the gas mixer is connected to the plant line that carries the coke oven and blast furnace gas mixture.

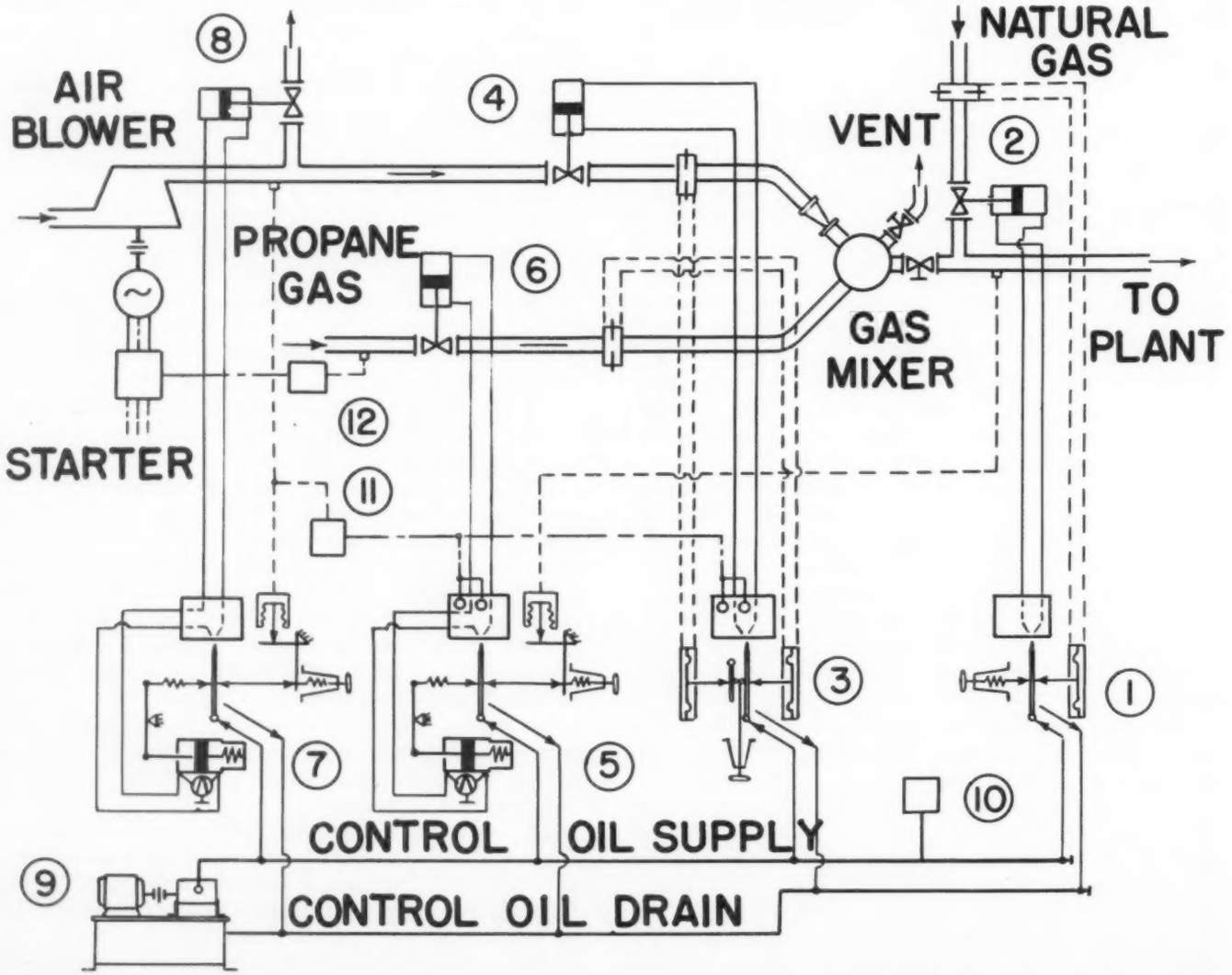
The control system is hydraulic and consists of two cylinder operated shutoff valves, two solenoid operated four-way valves, limit switches, pressure switches, relays, six regulators and a calorimixer. Each regulator operates a control valve equipped with a double acting hydraulic cylinder. Necessary pressure taps are provided in each line, as well as a pair of match butterfly valves that are used as variable area orifices for measurement of air and natural gas flows.

The control system provides the customary safety features combined with a fully automatic startup sequence. The shutdown of the station is semi-automatic and air blowers have to be stopped by the operator.

When the mixing station is off, both shutoff valves, both flow control valves and the two variable orifice butterfly valves are closed. The natural gas flow limiting control valve stays open all the time, except when the gas flow exceeds the set limit. A drop in pressure below the set limit in the main plant header actuates a pressure switch, which, if natural gas is available and the natural gas pressure switch has closed its contact, completes the electrical circuit to a time delay relay and through its contact, energizes the solenoid operated

Figure 1 — Gas mixing station supplements available natural gas with mixture of propane and air. Solid lines are control oil lines, dashed lines are signal lines and dash-dot lines are wiring. Legend is as follows:

1. **Natural gas flow regulator.**
2. **Natural gas flow control valve and cylinder.**
3. **Propane gas-air ratio regulator.**
4. **Air flow control valve and cylinder.**
5. **Gas pressure regulator.**
6. **Propane gas valve and control cylinder.**
7. **Air pressure regulator.**
8. **Air bleed control valve and cylinder.**
9. **Control oil pump unit.**
10. **Control oil pressure switch.**
11. **Air pressure switch.**
12. **Propane gas pressure switch.**



four-way valve that actuates the natural gas shutoff valve. While energized, this solenoid valve drives the natural gas shutoff valve wide open.

At the completion of the stroke, the cylinder actuates a limit switch which starts the no. 1 blower and also extends the start-up electrical circuit to the solenoid operated four-way valve that actuates the air shutoff valve. However, this solenoid valve is not activated until the blower supplies air at a pressure sufficient to activate the air pressure switch. The closure of the air pressure switch contact completes the electrical circuit to the solenoid valve and the air pressure valve is driven open.

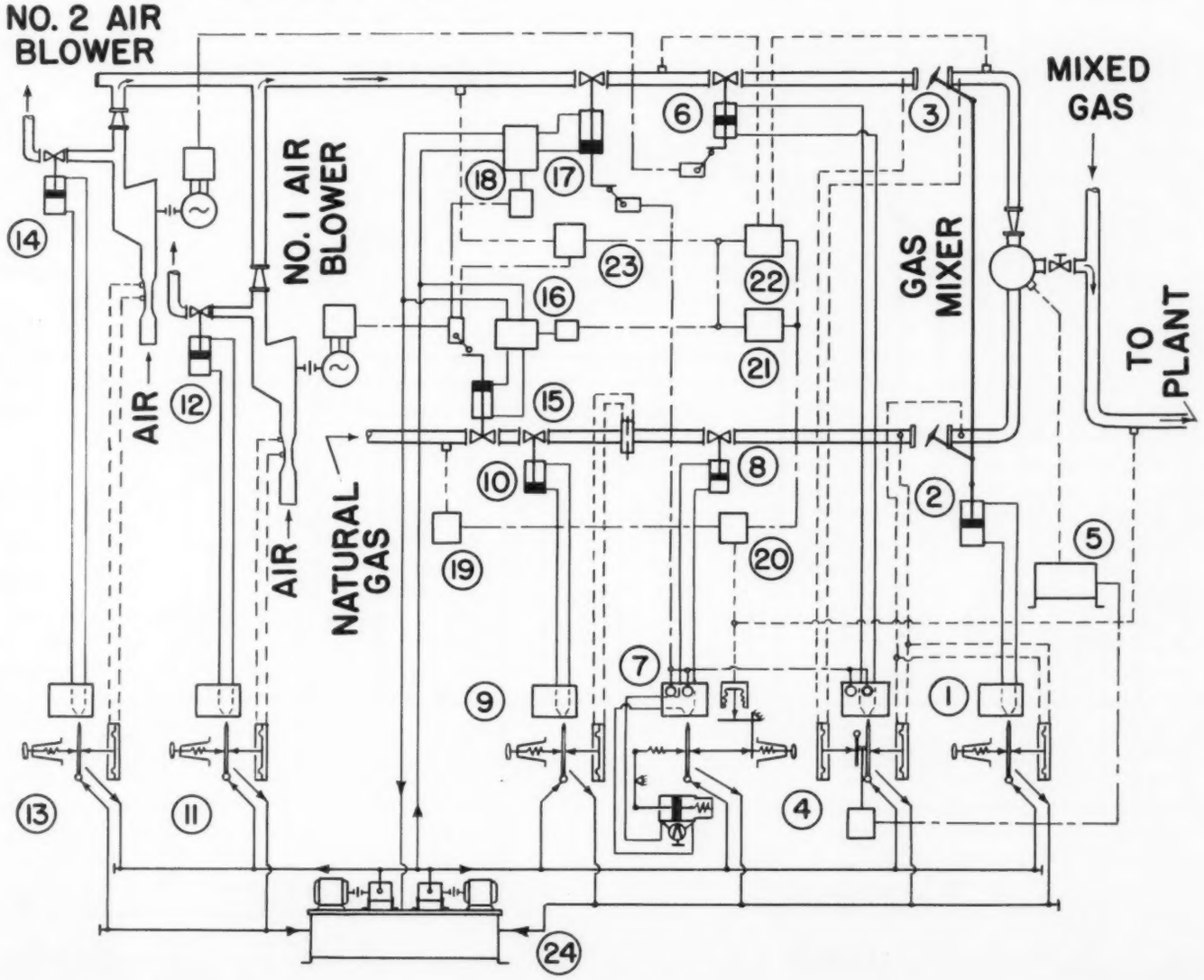
At the completion of its stroke, the air valve hydraulic cylinder activates a limit switch that operates solenoid valves of the air flow and natural gas regulators. Energizing of these solenoid valves connects the control cylinders of the flow valves to their appropriate regulators and the station is in operation.

The differential pressure switch across the air flow valve and the variable orifice is actuated as soon as the air shutoff valve is opened. The contact of this switch provides a by-pass for the contact of the delay relay. This relay opens the contact after a predetermined period.

The natural gas regulator measures the pressure in

Figure 2 — Gas mixing station supplements mixture of coke oven and blast furnace gas with a mixture of natural gas and air. Solid lines are control oil lines, dashed lines are signal lines, and dash-dot lines are wiring. Legend is as follows:

1. **Differential pressure regulator.**
2. **Natural gas variable area orifice (butterfly valve) and control cylinder.**
3. **Air variable area orifice (butterfly valve).**
4. **Natural gas/air ratio regulator.**
5. **Calorimixer.**
6. **Air flow control valve and cylinder.**
7. **Gas pressure regulator.**
8. **Natural gas flow control valve and cylinder.**
9. **Natural gas flow limiting regulator.**
10. **Natural gas flow limiting control valve and cylinder.**
11. **Surge regulator No. 1 blower.**
12. **No. 1 blower bleed control valve and cylinder.**
13. **Surge regulator No. 2 blower.**
14. **No. 2 blower bleed control valve and cylinder.**
15. **Natural gas shutoff valve and cylinder.**
16. **Natural gas solenoid operated four-way valve.**
17. **Air shutoff valve and cylinder.**
18. **Air solenoid operated four-way valve.**
19. **Natural gas pressure switch.**
20. **Mixed gas pressure switch.**
21. **Delay relay (delayed when energized).**
22. **Differential pressure switch.**
23. **Air pressure switch.**
24. **Control oil dual pump unit.**



the gas plant line and opens the natural gas control valve to bring it up to the desired pressure. Increase in differential pressure across the natural gas butterfly valve that functions as the variable area orifice causes the differential pressure regulator to open this valve to keep the differential pressure at the desired value. The butterfly valve in the air line opens at the same time. Also at the same time the differential pressure signals across both of the butterfly valves reach the natural gas/air ratio regulator which opens the air flow valve and controls the air in proportion to the natural gas flow. The calorimixer samples the mixture of natural gas and air and adjusts the ratio slider of the natural gas/air ratio regulator to compensate for errors created by possible inaccuracy of the two variable orifices and for variations in composition of the natural gas.

The two variable orifices provide a high turndown operation because the differential pressure across both variable orifices remain the same, regardless of the flow rate. The differential pressure regulator, instead, varies the effective area of the variable orifices in proportion to the rate of flow.

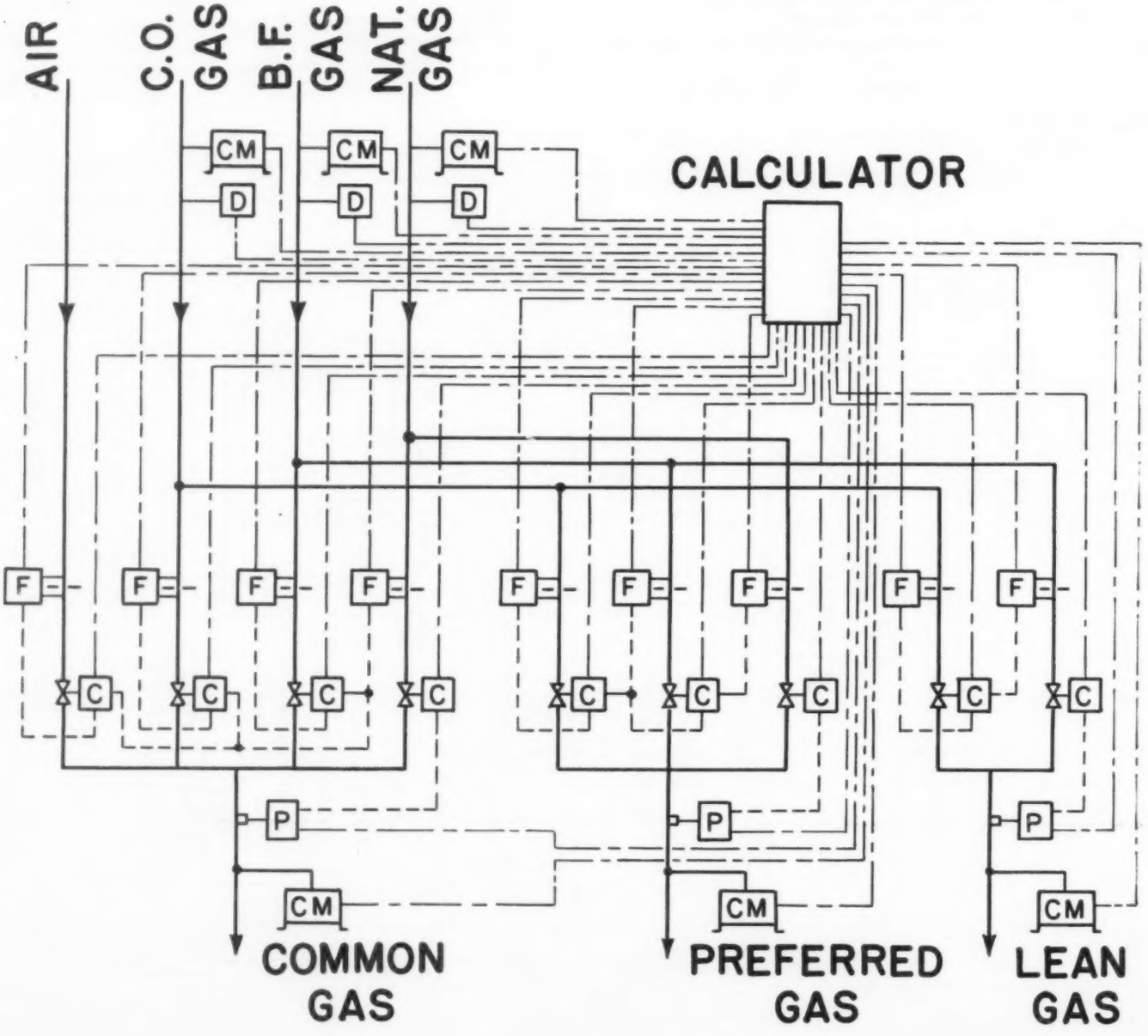
The second air blower is started when the capacity of the first air blower is inadequate. The start is initiated by a limit switch actuated by the air flow valve control cylinder when it reaches its fully open position.

Each blower has a minimum flow regulator that operates a bleed valve in the discharge line. The regulator maintains a minimum flow through the blower by bleeding the excess air and thus protects the blower from surging.

The natural gas flow limiting regulator maintains the maximum flow of natural gas at a rate that matches the capacity of the two air blowers. If only one air

Figure 3 — Design concept of triple gas mixing station to supply entire steel mill with three qualities of mixed gas. Dash lines are signal lines and dash-dot lines are wiring. Legend is as follows:

(C) Controller and actuator.
(D) Density transmitter.
(F) Flow transmitter.
(CM) Calorimixer.
(P) Pressure transmitter.



blower is available, the maximum natural gas flow setting is then reduced.

The station shuts down automatically when the main line pressure rises above the set minimum. The blowers, however, have to be stopped manually.

Loss of air causes the air shutoff valve and both flow control valves, as well as the variable orifices to close. Loss of natural gas supply shuts down the whole station, except the two air blowers which always have to be stopped manually.

Control oil is supplied by a dual pump unit with automatic startup of the stand-by unit.

Figure 3 shows a block diagram of a somewhat futuristic triple gas mixing station that supplies an entire steel mill with three qualities of mixed gas.

The station utilizes all available coke oven gas, all blast furnace gas but that used by the stoves, and it uses natural gas and natural gas and air mixture as supplementary fuels.

The outputs of this triple gas mixing station are lean gas, which is a mixture of coke oven gas and blast furnace gas; preferred gas, which is a mixture of coke oven gas, natural gas and blast furnace gas; and common gas, which is a rich mixture of coke oven gas and blast furnace gas supplemented by mixture of natural gas diluted by air.

This gas mixing station is directed by an electronic calculator. The calculator is supplied with the necessary information, i.e., heating value and density of incoming gases, heating value and flow rate of the outgoing mixtures, and the flow rates of the individual gases that form the mixtures. The calculator scans periodically the incoming data, performs the necessary calculations and then resets the ratios between the individual flows to provide the optimum quality of mixed gases and the maximum utilization of the by-product fuels.

The controls are of the volumetric ratio type and are equipped with conventional manual ratio adjustments that make it possible, if it is required, to by-pass the calculator and operate the stations in the same manner as it is done today.

From the examples of the gas mixing stations described, it becomes obvious there is available today an ample variety of control systems for gas mixing stations.

The control system illustrated in Figure 1, has low turndown and manual startup and shutdown. As such, it is eminently applicable for installations where a range of 10 to 100 per cent of the supplementary gas is always required. The gas mixing station, as shown, is not equipped with a calorimixer, however, the calorimixer can be added to the system if the application requires very accurate control of the heat value.

Figure 2 shows a control system that, by today's standards, is quite modern. The controls are capable of at least 50 to 1 turndown in flow and its automatic startup features provide control characteristics that are required for gas mixing stations truly on stand-by duty, in plants, where coke oven gas supply exceeds the demand most of the time. The calorimixer is an optional feature, although it is used most of the time with control systems of this type.

Variation of these two control schemes is a control system for gas mixing stations that employ more than two constituents to obtain mixed gas. Such control systems are not common in the steel industry, and each system reflects the needs of the individual plant. However, the principles used for controlling these gas mixing stations are basically the same as illustrated in Figures 1 and 2.

Another variation, not included in either schematic, is a control of the desired heat value of the mixture as a function of the proportion of the two mixed gases.

Need for such an arrangement arises when incoming make-up gas has large variations in heat value. In order to obtain a constant flow factor, the ratio of the mixture has to change as a function of the heat value of the mixture. Fortunately the relationship between the mixed gases ratio and the mixture heat value is a direct function and a simple control system can accomplish it satisfactorily.

Figure 3 shows a radically new approach to gas mixing. The general concept is that all gas for the steel mill is provided by the gas mixing station, and with the exception of stoves, there are no direct users of unmixed gas.

The system, as such, has several advantages:

1. Both blast furnace gas and coke oven gas are used in some quantity throughout the plant, which greatly increases their consumption and reduces, if not eliminates completely, their waste.

2. For reheat furnaces and other preferred users the station makes high quality preferred gas, which besides good combustion characteristics features also identical flame and heat transfer characteristics.

3. The electronic calculator adjusts continuously the flows and mixtures of the individual gases and utilizes the maximum of the by-product gases.

The system, of course, has its drawbacks; a gas mixing station that handles gas for an entire plant is huge. It also has to be failproof, because the whole plant depends on it. Furthermore, the gas distribution network has to be compatible with it, and it is very doubtful that an existing plant can apply this concept without very expensive changes. However, a system like this could and should be considered for a new mill or an existing mill where plans are being made for a complete modernization of the gas distribution.

At this point, it should be stressed that unlike systems shown in Figures 1 and 2, this new system, to the best knowledge of the writer, has not been installed anywhere or offered to anyone. In designing the system shown, an attempt has been made to please everybody, and, as usual, it probably satisfies no one. However, it is probable that some features of such a concept might be advantageous to some steel plants. The control system is inherently flexible, so that it can be changed to make it applicable to almost any condition.

To conclude, it can be said that the control systems have kept pace with the requirements of the gas mixing stations, and that control systems are available for practically any application.

The problem today is not how to design the control system for the job, but to choose the proper one from those available. Operating conditions, availability of fuels, production problems, quality of product, burning equipment, design of furnaces, etc., are the criteria that influence the proper selection.

The best results can be accomplished by close cooperation between the user who can and should accurately define the problems and requirements of the

gas mixing station, and the control system manufacturer or designer, who, from experience can offer optimum solutions for the given installation.

Gas mixing stations, designed under these conditions, cannot fail to give full satisfaction to the user, and as such, are also a source of pride to the supplier of the control equipment.

Discussion

PRESENTED BY

R. A. LAMBERT, Superintendent, Steam Efficiency and Combustion, Pittsburgh Works, Jones & Laughlin Steel Corp., Pittsburgh, Pa.

N. R. KIRKDOFFER, Superintendent, Power, Steam and Combustion Depts., Indiana Harbor Works, Inland Steel Co., East Chicago, Ind.

L. CIZMADIA, Fuel Engineer, Utilities Dept., Fairless Works, United States Steel Corp., Fairless Hills, Pa.

IRVING ROZIAN, Supervisor, Process Research and Development, Steel Div., Ford Motor Co., Dearborn, Mich.

IVAN AKEY, Superintendent Combustion, Great Lakes Steel Corp., Div. of National Steel Corp., Ecorse, Detroit, Mich.

JOHN VOGEL, Product Section Supervisor, System Control Sales Div., Cutler-Hammer, Inc., Milwaukee, Wis.

J. K. SAZAVSKY, Chief Application Engineer, GPE Controls, Inc., Chicago, Ill.

R. A. Lambert: As the author implies, each installation must be tailored to meet individual plant requirements but nonetheless, automatic principles should improve operation.

In 1950 the Pittsburgh Works plant of Jones & Laughlin installed a gas mixing station which is still operating and fully automatic, with one exception; that is, in case of gas booster shutdown, the steam turbine drive must be started manually. The latter occurs, however, only for outage repairs.

The author mentions that control systems have been designed for: (1) uniform heating value per cu ft, (2) uniform specific gravity, (3) uniform combustion air requirements and (4) uniform flame characteristics. Our Pittsburgh Works station is designed for uniform combustion air requirements. In our case, this must be obtained in order to secure proper fuel-air ratio at the various heating units for which gas is supplied. Otherwise we would, of necessity, require some type of corrector for the primary measuring element.

The author states that, if proper fuels are available in unlimited quantity, two, three or all four of these aforementioned characteristics can be satisfied. We presume the author means that any single one of these four items can be satisfied but certainly not all four of them simultaneously. We would appreciate his comments in more detail in this respect.

In order that our mixing station at Pittsburgh Works obtain uniform combustion air requirements, we use the so-called "Wobbe" factor, which is to mix any gases so as to maintain a constant equated to the heating value divided by the square root of the specific gravity of the primary gas. We mix the natural gas and clean blast furnace gas to such a constant in order to satisfy the similarly calculated constant derived from the use of the coke oven gas. Is this the method that the author has in mind in order to obtain combustion air requirement uniformly or is there some other procedure which he uses?

My third question has to do with uniform flame characteristics. It would seem to me that uniform flame characteristics can only be obtained provided that the individual constituents of the gas do not vary percentage wise. Does Mr. Sazavsky concur with this?

N. R. Kirkdoffer: At Inland we have several gas mixing stations with controls similar to those in Figure 1 of Mr. Sazavsky's paper. This equipment is continuing to give us good service as it has for many years.

We are in the process of constructing a new natural gas-air mixing station which we shall use to supplement and stabilize our coke gas system. In designing this station we tried to make it as dependable as possible. By using jet compressors, the energy for compressing the air comes from the high pressure natural gas. Since jet compressors have no moving parts, they should be practically free from mechanical failure.

By using four jets of different sizes, we will be able to vary the natural gas input from zero to 450 mcfhr in 30 mcfhr increments. Flow rates may be changed either remote manually or automatically to maintain a predetermined coke gas system pressure. The normal control medium is clean, dry, compressed air from the plant air system. If the air supply should fail, natural gas will be automatically fed into the instrument air system with no interruption of operation.

Course control of the Btu value of the mixture will be attained by characterizing the jets and by using an air header pressure control. Fine control will be attained by means of a calorimeter which will adjust the set point of the air header pressure control. In the event of a power failure, to the mixing station, we would lose the fine Btu control, but otherwise, the station will continue to function automatically.

Although we have had no operating experience with this type station, we expect it to give satisfactory service with a maximum of reliability.

L. Cizmadia: At United States Steel, Fairless Works, we have an installation employing 15 equal sized jets supplementing coke oven gas with a natural gas and air mixture, based on line pressure deviation from the set point. The control system is entirely pneumatic, utilizing plant air as a primary supply, backed up with a standby compressor activated by a pressure switch at a minimum pressure setting. Initially this station required operators on continuous duty; however, through revisions to the control system and the transmission of all pertinent information from this station to a centralized receiving center it has been operating three and a half years nonattended.

You mentioned a turndown of 50 to 1 in your second type mixing station. Our station can supply a maximum of 1,500,000 cfhr natural gas down to zero and control

line pressure within + or $-\frac{1}{8}$ psig.

The second type mixing station mentioned, utilizing a calorimeter for control of air-gas ratio, is the most common type. The third type mixing station is desirable for supplying various gas ratios to best meet requirements of the various processes. We can see great possibilities for a station of this type installed in a new plant with facilities designed to best utilize its potential.

Facilities of all kinds should be designed on a maintenance and operating manhour requirement basis. Mixing stations and related facilities, where nothing productive is gained should always be designed as unattended with a minimum of maintenance manhours.

In closing I would like to ask Mr. Sazavsky the following questions:

1. What is the time lag between sampling of gases on a calorific basis and readjustment of controls to correct for any deviation?

2. In Figure 1 you mention that a manual adjustment is necessary to correct for heating value changes in the propane gas. How do you determine the need for readjustment?

Irving Rozian: Have there been any fire difficulties with natural gas-air mixtures in lines which had formerly carried coke oven gas or mixed gas (due to pyrophoric deposits sometimes left from the coke oven gas)?

Ivan Akey: Is it always necessary to use a mixing chamber in these installations? I noticed it was shown in both of the figures. Are there occasions where it is not necessary? What is the determining criteria there for?

John Vogel: The question was asked about the time lag which you would have using an instrument such as a calorimixer on a control system. You can look at the time lag from two different standpoints, the first concerns measurement of heating value change in the instrument itself, and the second consideration is the transport time lag of the sample. This transport time lag as far as measurement is concerned is determined by two factors. The first is the size of the sample line to the instrument. The larger the sample line, of course, the longer it will take for gas measured to get from the sample point to the instrument. The second is the transport lag in the instrument itself. This instrument transport lag is determined by the upper range of heating value that the instrument is designed for. The other instrument factor is thermal time lag which is the same for all ranges.

The calorimixer is designed for very fast response and a 1000-Btu range instrument will show a five per cent change in heating value in about 20 sec. By comparison the thermeter which is a little bit slower would make a similar response in about 56 sec, and the calorimeter would show a five per cent change in about $5\frac{1}{4}$ minutes. The amount of response time varies inversely with the accuracy of the instrument.

The time required to measure heating value change is important in control systems from a stability standpoint. An interrupted mechanism is used with the thermeter and calorimixer and sends correcting control signals about once every 20 sec. In this way correcting signals are timed so they are not more rapid than the instrument can measure and hunting is avoided.

Three key words which may be used when considering automatic control requirements for gas mixing applications are quantity, quality and economy. The system should, of course, provide sufficient quantity of gas to meet load requirements. Equally important, the gas must be of proper quality from the standpoints of heating value and specific gravity for efficient functioning of the load supplied. Underlying these first two considerations of system performance is the requirement for operating economy. We certainly agree, therefore, with the point made by the author that the basis of application success is the careful selection of one of the many available types of mixing control systems to meet the requirements of the particular installation.

One of the key words suggested above was "quality." Perhaps the most obvious consideration in this area concerns the energy per unit volume of gas production. The fundamental function, after all, of a gas mixing station is to provide energy in convenient, useful form. Therefore, the control for such a system must of necessity involve controlling the unit energy level of the output. Approximate control and measurement can be obtained inferentially by volumetric proportioning as in the first control system described by Mr. Sazavsky, but certainly for accuracy, actual measurement should be made of heating value.

Examples of the importance of controlling heating value directly in gas mixing systems may be of interest. The effect of variations in the characteristics of gases being mixed upon the final mixture depends, of course, on the relative proportions of constituents. With straight volumetric proportioning, it is almost certain that unavoidable errors will occur due to the range in flow which must be covered. The degree of precision required in a volumetric proportioning system to maintain heating value output within a given tolerance may be expressed mathematically. Considering ΔF as the change in flow of one gas in a binary mixture to produce a one per cent change in mixture heating value, then:

$$\Delta Fa = \frac{\text{mixture heating value}}{\text{per cent volume gas ``a'' } \times 0.01(\text{heating value gas ``a'' } - 1.01 \times \text{mixture heating value})}$$

As examples consider the following:

a. 900-Btu propane-air mixture
35 per cent propane (2550 Btu)
65 per cent air

$$\Delta F(\text{propane}) = \frac{900}{0.35\,(2550 - 1.01 \times 900)}$$

$$1.57 \text{ per cent}$$

b. 725-Btu natural gas-air mixture
69 per cent natural gas (1050 Btu)
31 per cent air

$$\Delta F\ (\text{natural gas}) = \frac{725}{0.69\,(1050 - 1.01 \times 725)}$$

$$3.31 \text{ per cent}$$

From the above examples the volumetric proportioning problem for the propane-air mixture is twice as critical as for the natural gas-air mixture.

Mixing systems utilizing Btu control were illustrated in Figures 2 and 3 of the paper presented. Both these systems make use of a calorimixer which is a control instrument designed to respond quickly to changes in

the heating value of a gas mixture and to initiate control impulses to maintain the desired or set heating value. The calorimixer itself does not indicate heating value and therefore it is generally used with a recording calorimeter which will supply an indication and record of Btu's per cu ft. Where accuracy of heating value measurement is less critical, a thermeter can be used which combines heating value control with indicating and recording functions in one instrument.

The other quality consideration mentioned besides heating value is the specific gravity of the output gas. Variations in this characteristic will affect the rate of gas flow and thereby the rate at which energy in the gas can be utilized at the point of consumption. The heat input factor or index combines the characteristics of energy per unit volume and gravity into a single expression $Hv/\sqrt{g}$.

To interchange or supplement a basic gas supply without effecting the load performance, therefore, this heat input factor for the mixture should be kept constant. In Figure 1, for example, the propane-air mixture heat input factor should equal the heat input factor of the natural gas. Fortunately, a direct relationship exists between the heating value and specific gravity of a mixture such as propane and air. By holding mixture heating value constant, therefore, the mixture heat input factor can be established at the proper value. If the natural gas used in station No. 1 has a heating value of 1000 Btu's per cu ft and a specific gravity of 0.61, its heat input factor is $1000/\sqrt{0.61} = 1283$. Considering the required heat input factor for the propane-air mixture, we have the following equations:

1. $$\text{Heat input factor} = \frac{\text{Hv mixture}}{\sqrt{\text{g mixture}}}$$

2. Hv mixture = Hv propane × per cent V propane × 0.01

3. g mixture = g propane × per cent V propane × 0.01 + g air × (100 − per cent V propane) × 0.01

4. Substituting,

$$1283 = \frac{\text{Hv propane} \times \text{per cent V propane} \times 0.01}{\text{g propane} \times \text{per cent V propane} \times 0.01 + \text{g air } (100 - \text{per cent V propane})\ 0.01}$$

5. $$1283 = \frac{2550 \text{ per cent } V_p \times 0.01}{1.527 \times \text{per cent } V_p \times 0.01 + 1\ (100 - \text{per cent } V_p) \times 0.01}$$

6. Solving the above equations we have, Hv = 1468 Btu per cu ft

Thus by controlling to this heating value, the desired heat input factor of the mixture is maintained.

Returning to Mr. Sazavsky's final point, given understanding and proper statement of application requirements by the user, and careful consideration of necessary control features by the designer, the criteria of performance; quantity, quality and economy should be met.

J. K. Sazavsky: First Mr. Lambert asked if uniform specific gravity and uniform combustion air requirement as well as uniform flame characteristics can be all maintained at the same time. The answer is yes, as stated in the paper. This, of course, can be accomplished only by maintaining equal proportion of the mixed gases and it can be done only if unlimited quantity of the gases to be mixed is available. Therefore, the gas mixing station cannot operate on the gas make-up as is customary, and the excess of the gases not used has to be directed to users that do not require gas of this uniform quality.

Regarding the heat flow or "Wobbe" factor, it is definitely used as basis for calculations of the proper gas ratios to obtain a gas with certain combustion characteristics.

Sometimes we control gas mixing stations on the basis of regulated heating value per cu ft, but the final heating value is readjusted as function of the ratio of the two gases mixed. The result is a mixture with constant heat flow factor.

In answer to the discussers from Inland Steel Co., the jet gas mixing stations have their use just as volumetric gas mixing stations. It was stressed in the paper, that operating conditions, availability of fuels and all the other criteria mentioned should be considered and govern the selection of the gas mixing station to be used. Basically, the jet gas mixing stations can be used only where the mixed gas is fed into a low pressure system. They are very reliable as there are very few components and the station is not dependent on external source of power. These stations require very little control as their characteristics compensate for pressure fluctuations. This type of station was not mentioned in the paper because the 30-min limit did not allow it.

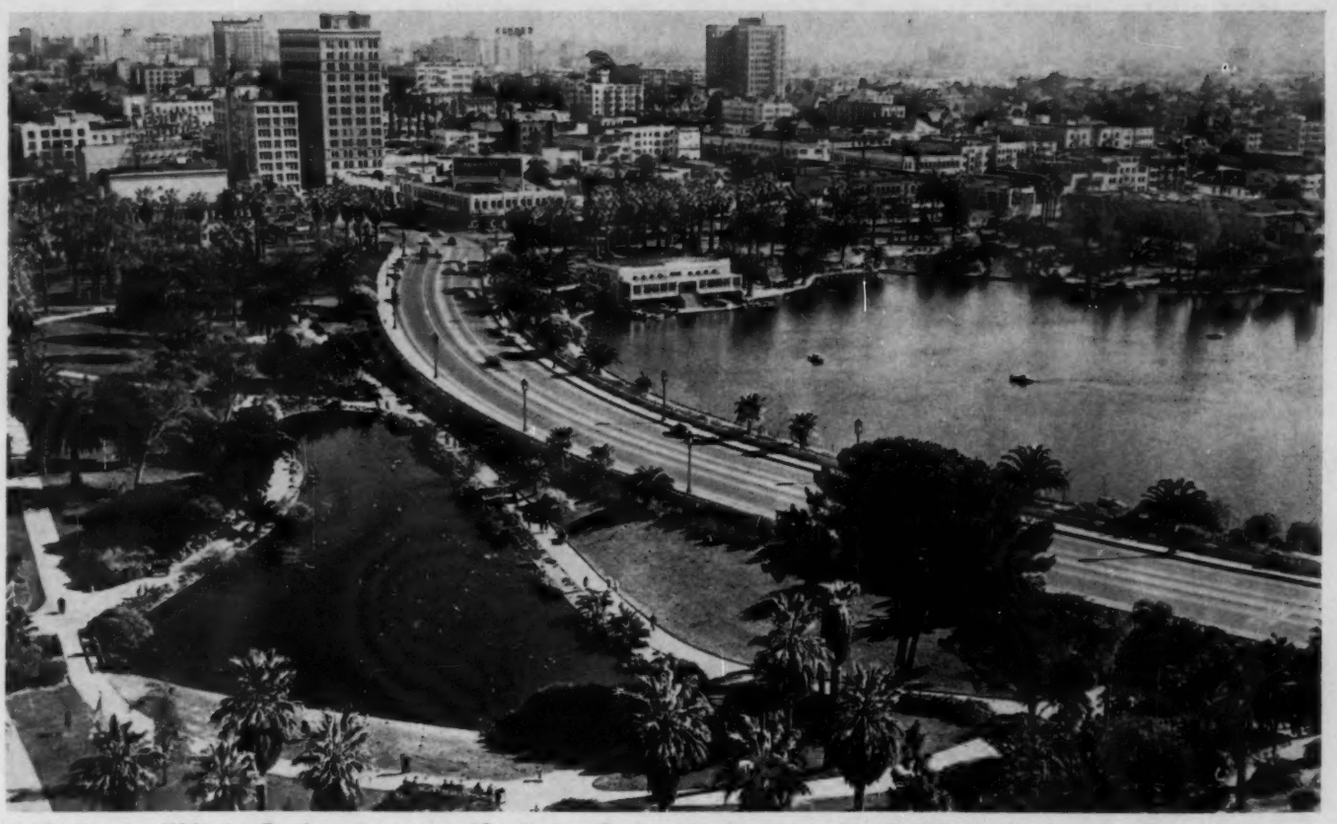
Mr. Cizmadia's comments indicate that the jet gas mixing station is very good and efficient in its operation. Regarding the 50 to 1 turndown of volumetric mixing stations he mentions, we would like to point out that that is comparable to the turndown of one jet of the jet type gas mixing station. To accomplish larger turndowns of volumetric stations, two or three volumetric gas mixing stations of properly ratioed capacities can be used in parallel.

The manual adjustment required to correct for changes in heating value of incoming gases in the first and simplest type of gas mixing station is done on the basis of supervisory instruments, not shown on the schematic. Such adjustments are infrequent, as the quality of the incoming gas changes gradually over a long period of time.

To reply to Mr. Rozian we do not know of any problems he mentions.

While we whole-heartedly agree with Mr. Vogel's statement that the quantity, quality and economy are the basic criteria from the user's viewpoint for the selection of the proper gas mixing station, we want to point out that the other criteria mentioned in the paper have to be considered too. The use of the calorimixer in our viewpoint is necessary only when high accuracy and high turndown of the mixed gas is to be expected. Obviously calorimeter will be used as well so that records are available. Stations that do not have a large turndown will maintain a fairly accurate heat value of the mixed gas with volumetric control only.

In answer to Mr. Akey, the gas mixing chamber on the schematics was shown only for convenience. In majority of cases, where long runs of pipe are available and the velocities of the two gases mixed are approximately the same, a gas mixing chamber is not required. However, if these conditions do not exist, a gas mixing chamber is essential for good performance. ▲



World-famous Wilshire Boulevard crossing MacArthur Park, with downtown Los Angeles in the background.

PROGRAM

AISE Western Meeting

The Statler Hilton
Los Angeles, California
February 27, 28, and March 1, 1961

MONDAY, FEBRUARY 27

8:30 am—REGISTRATION—
Foyer-Ball Room Floor

9:00 am—TECHNICAL SESSION—
Sierra Room

Chairman: S. F. Mazur, Electrical Superintendent, Pacific States Steel Corp., Niles, Calif.

Harry Riegel, Superintendent of Utilities, Iron & Steel Div., Kaiser Steel Corp., Fontana, Calif.

"Automation and Process Control in Soviet Iron and Steel Industry," by W. E. Miller, Manager, and R. M. Sills, Application Engineer, Metal Rolling & Processing Engineering, Industrial Engineering Operation, General Electric Co., Schenectady, N. Y.

"The Power Distribution System of an Integrated Steel Plant," by Donald Stewart, Jr. Electrical Maintenance Engineer, Electrical Maintenance Dept., Kaiser Steel Corp., Fontana, Calif.

"Operational Results of Automatic Gage Control on a Hot Strip Mill," by R. M. Peeples, Supervisory Engineer, and E. H. Christian, Engineer, Control Dept., Allis-Chalmers Manufacturing Co., Milwaukee, Wis.

2:00 pm—TECHNICAL SESSION—
Sierra Room

Chairmen: Louis E. Ringger, Assistant Works Engineer, Columbia-Geneva Steel Div., United States Steel Corp., Provo, Utah

J. B. Wylie, General Superintendent, Judson Steel Corp., Oakland, Calif.

"Ceco's Ochiltree Works Modern Electric Furnace Bar and Merchant Mill," by W. B. Jacobsen, Works Manager, Ochiltree Works, Ceco Steel Products Corp., Lemont, Ill., and Lawrence S. Barker, Jr., Project Manager, The Rust Engineering Co., Birmingham, Ala.

"The Rolling of Ultra-Thin Tinplate," by Dr. M. D. Stone, Manager, Development, United Engineering and Foundry Co., Pittsburgh, Pa.

"Outstanding Application Developments in Mill Electric Drive Systems," by W. H. Dauberman and S. V. Stickler, Jr., Sponsor Engineers, Metal Working Section, Industrial Engineering Dept., Westinghouse Electric Corp., East Pittsburgh, Pa.

"The Story of Atlantic City," by W. F. Pruden, Chief Engineer, Columbia-Geneva Steel Div., United States Steel Corp., San Francisco, Calif.

TUESDAY, FEBRUARY 28

9:00 am—TECHNICAL SESSION— Sierra Room

Chairmen: Jerome L. Lindberg, Superintendent of Mechanical Dept., Pueblo Plant, The Colorado Fuel and Iron Corp., Pueblo, Colo.

R. J. Tremblay, General Manager, Pacific Coast Div., Bethlehem Steel Co., Los Angeles, Calif.

"Solutions to Basic L-D Plant Layout Problems," by J. W. Irvin, Project Engineer, Kaiser Engineers, Div. of Henry J. Kaiser Co., Oakland, Calif.

"Natural Gas Injection into the Blast Furnace at Lone Star Steel Co." by Fred W. Farmer, Combustion Engineer, and J. C. Moreland, Junior Combustion Engineer, Lone Star Steel Co., Lone Star, Texas

"Oxy-Fuel Processes Increase Steelmaking Rates," by E. F. Kurzinski, Manager, and R. D. Jones, Development Engineer, Applied Research and Development Div., Air Products, Inc., Allentown, Pa.

2:00 pm—TECHNICAL SESSION— Sierra Room

Chairmen: R. L. Dowell, Superintendent Cold Reduction, Columbia-Geneva Steel Div., United States Steel Corp., Pittsburg, Calif.

W. L. Murphy, Assistant General Manager, Pacific Coast Div., Bethlehem Steel Co., South San Francisco, Calif.

"The Production and Uses of Aluminized Steel," by John D. Sprowl, Research Engineer, Dept. of Metallurgical Research, Kaiser Aluminum & Chemical Corp., Spokane, Wash.

"Use of the Open Coil Process to Change Composition and Produce Improved Sheet Steels," by John A. Bauscher, Vice President—Research, Lee Wilson Engineering Co., Inc., Cleveland, Ohio.

"The Application of a Non-Contacting Measurement System for Coating Weights on Continuous Galvanizing Lines," by James E. Reider, Area Manager, Industrial Nucleonics Corp., Columbus, Ohio

7:00 pm—INFORMAL STAG DINNER— Pacific Ball Room

Speaker: H. C. McClellan

WEDNESDAY, MARCH 1

8:30 am

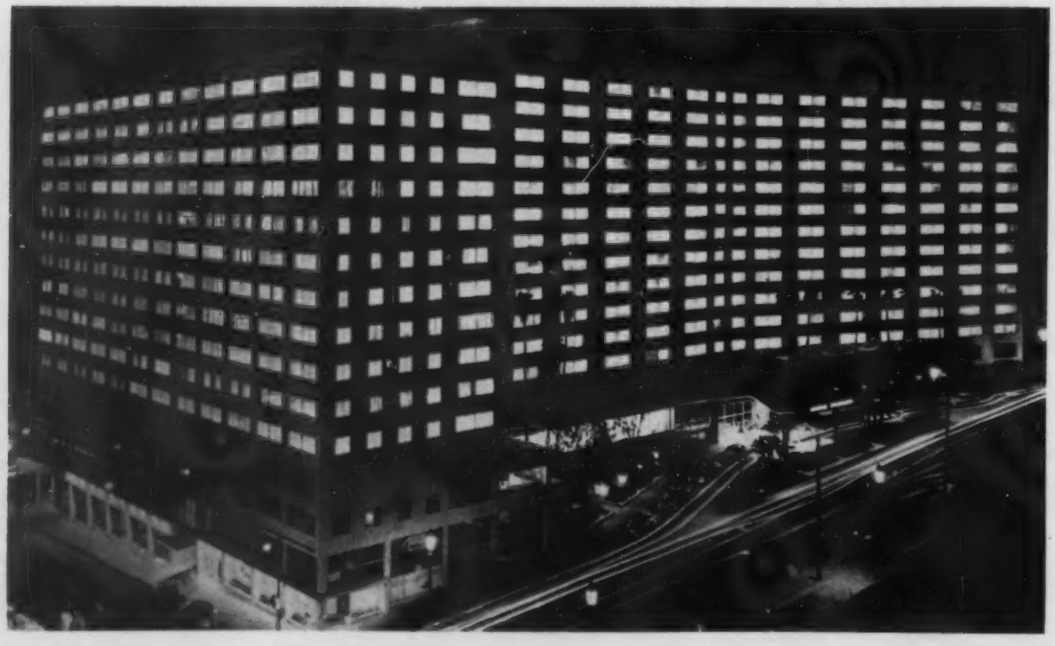
Inspection Trip to Fontana Works of Kaiser Steel Corp. Buses will leave The Statler Hilton at 8:30 am.

hotel reservations

Write direct for hotel reservations to The Statler Hilton, Los Angeles, Calif., giving time of arrival and type of accommodations desired. Reservations should state that they are for AISE Western Meeting.

transportation

Individuals or groups desiring assistance in planning their trip should get in touch with the office of American Express Co., in their respective cities or with any local travel agency.



Night view of The Statler Hilton, headquarters for the 1961 AISE Western Meeting.

GENERAL

Developments in the Iron and Steel Industry during 1960

by I. E. MADSEN

TO a casual observer, 1960 might seem like a bad year for steel. Operations started the year with a rush. Business was so good that it was difficult to meet demand. The pent-up orders carried over from the steel strike and the eagerness on the part of the buyers to build inventory kept mills going at high rates for the first part of the year. The contrast was therefore bitter when the rate dropped early in the summer and did not pick up. As the year ended, operations floated around half of so-called capacity.

This capacity figure, however, is extremely deceptive. The casual observer again may think that an operation rate of 50 per cent means that only half of the industry is operating and, since steel means so much to industrial operations as a whole, a gloomy, distorted impression results. Also, what industry does operate for extended periods at maximum capacity?

A more logical approach is to think that the steel industry has developed adequate surplus capacity to take care of defense and other needs and perhaps to take up the slack after the strikes which seem to be so prevalent in the industry.

In 1960 the final ingot output was slightly under 100,000,000 tons of steel. *This is good!* If one totals the total amount of steel which was made in the last five years, 1956 to 1960, he will find that the average rate

was 101,000,000 tons. This does not represent bad times. This is the rate that corresponded with peak capacity industrial operations in other segments of the American economy.

Going back still further, in the 5-year period from 1951 to 1955, the average production was 103,000,000 tons, in a period in which steel was still needed to satisfy some pent-up demands remaining from World War II. In the previous 5-year period, 1946 to 1950, production averaged 83,000,000 tons, but more would have been made if it had not been for strikes and capacity limitations.

Since many economists say that this is a growing economy, the quick conclusion is that steel usage must increase. The fact is, it has, but tons do not necessarily give a true measure of steel use. In the past few years, there have been definite trends to make better steels, to increase yields, to furnish better quality. This means that less steel can go further. Examples are the trend to the use of thin tinplate, and the development of stronger steels, so that less steel is needed to do a given job. In addition, the manufacturers of finished products are designing more closely, with an eye to conservation of materials. The upsurge of the compact car as such means that finished products may require less materials.

Does the present low operating rate mean that further steel plant construction is not required? On the contrary, in order to compete with foreign markets, to improve economy and to produce better steels, the steel industry must modernize, rehabilitate, speed up.

Actually, the steel industry is at a crossroads. At one time steel was so cheap that additional costs which might be reflected in price increases had little effect on its competitive situation. This is now changed. The increases in steelmaking costs since World War II, primarily brought on by increased labor costs in the steel and supplier industries, have put steel in the position where any increase in prices may mean some sales loss to a competitive material. In addition, such increases add another disadvantage to American steelmakers when competing with foreign steelmakers.

Steel usage seems to be leveling off on an ingot tonnage basis.

The actual difference in usage compared with production in the recent periods can be obtained by checking the export-import figures for the various periods. From 1946 to 1950, an average of some 5,000,000 tons of steel were exported; from 1951 to 1955, exports averaged 3,900,000 tons annually and from 1956 to 1960 exports averaged 4,150,000 tons. Annual average imports of steel in those periods were 640,000 tons in the 1946–1950 period; 2,100,000 tons in the 1951–1955 period, and 3,100,000 tons in the 1956–1960 period, with a peak of 5,515,909 tons in 1959, largely because of the strike. Thus, a net annual tonnage of 4,300,000 tons went abroad in the 1946–1950 period; 1,800,000 tons in the 1951–1955 period; and 1,000,000 tons in the 1956–1960 period. Taking exports and imports into account, steel usage averaged 101,300,000 tons in the 1951–1955 five-year period; 100,300,000 tons in the 1956–1960 five-year period; and assuming net imports in 1960 at 800,000 tons, steel usage in 1960 was about 101,100,000 or 800,000 tons over the last 5-year average—not a bad year. Inventory adjustments would have little effect on the figures for these average period trends.

In the first eight months of 1960 imports totaled 2,600,000 net tons. Exports in this period totaled 2,100,000 tons. As a result it was estimated that at the end of the year there would be an 800,000-ton surplus of imports over exports.

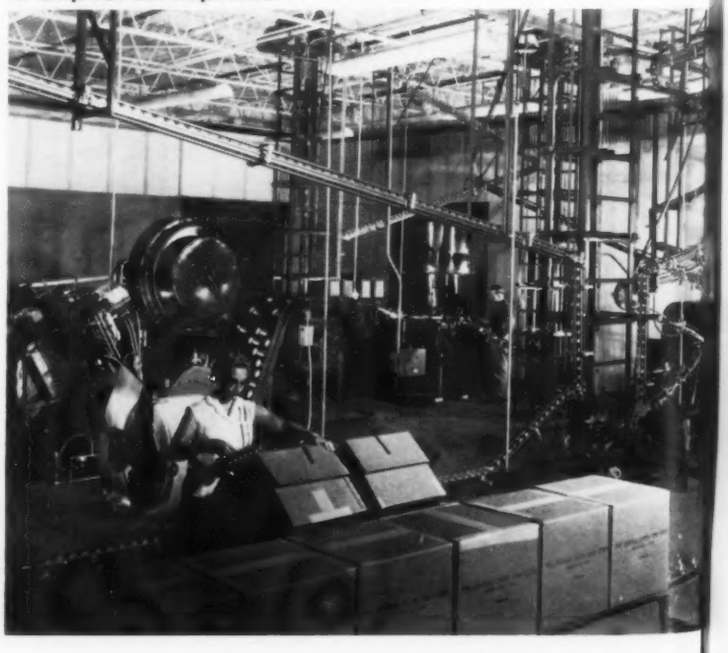
In the first half of 1960 production went along at record rates. Total production for the first six months was 60,754,095 tons of ingots, equivalent to 82.0 per cent of capacity. However, production slowed down and total production for the whole year 1960 was about 99,277,760 tons or 66.8 per cent of the 1960 capacity of 148,570,970 tons. Of this, open hearth production totaled 86,370,948 tons (68.2 per cent of capacity), bessemer production totaled 1,189,637 tons (35.0 per cent of capacity), basic oxygen process steel totaled 3,345,826 net tons (80.5 per cent of capacity), and electric furnace steel totaled 8,371,349 net tons (58.2 per cent of capacity). In 1959, production totaled 93,446,132 tons, which was 63.3 per cent of 1959's capacity of 147,633,670 tons. Production in 1959 consisted of 81,668,997 tons of open hearth steel, 1,380,283 tons of bessemer steel, 1,864,338 tons of basic oxygen process steel, and 8,532,514 tons of electric furnace steel. It will be noted that in 1960 open hearth and basic oxygen process steel tonnage was greater than in 1959, and bessemer and electric furnace steel was somewhat less.

Blast furnace production in 1960 was about 67,800,000 net tons from furnaces or 70.2 per cent of the 1960 capacity of 96,520,630 net tons compared with 61,227,050 net tons of pig iron and ferro-alloys in 1959. Coke production was about 59,000,000 tons in 1960.

Shipments of finished steel in 1960 totaled about 71,000,000 net tons compared with 69,377,067 net tons in 1959.

The American Iron and Steel Institute announced in December that it plans to stop issuing weekly figures for the steel operating rate expressed as a percentage of capacity starting in 1961. It will also stop making weekly forecasts of tonnage of raw steel to be produced.

Fully mechanized can line shown fabricates aluminum cans of various sizes. This development is spurring changes in tinplate development.



There was also some question as to whether it would announce a figure for total steel capacity. Data to be issued will include only weekly production figures for the previous week, and a percentage comparison between that and the previous week. The index number relating the week's production to the average weekly output in 1957, 1958 and 1959 will also be used, instead of the 1947–1949 base used previously.

The steel industry now consists of some 250 competing companies in the United States who have plants in 279 communities in 33 states. In almost every plant, efforts are being made to increase efficiency.

There has been a marked increase in hot rolling capacity in the country. A survey made by the AISI shows that this totaled 113,785,590 net tons of hot rolled steel sheet, bars, plates, structural shapes, rails and other products as of January 1, 1960. This is over 10,000,000 net tons higher than in 1957, the most recent prior year for which finishing capacity had been determined.

Hot rolled sheet capacity of 39,500,000 tons in 1960 is up nearly 6,000,000 tons over the 1957 level. Capacity for coils to be further processed into black and tinplate is up to 10,800,000 tons, an increase of 1,500,000 tons. Heavy structural shape capacity totals 8,200,000 tons, and bar capacity of all kinds totals 18,300,000 tons. Cold rolled sheet capacity is now a record 22,000,000 tons, an increase of 2,700,000 tons. Electrolytic tinplate capacity is 7,000,000 tons compared with 5,500,000 tons in 1959.

At the beginning of 1960, the steel industry budgeted something like $1,600,000,000 for capital expenditures. This figure was some $640,000,000 above that of 1959, and only $150,000,000 below the industry's record outlay. Despite the fact that business slowed down during the year, the cutback in capital expenditures was nowhere near as marked. A few outright cancellations were made, and in a number of cases decisions were postponed. On many projects, commitments had probably gone too far to economically cut back. Also many plants must modernize to compete.

It is estimated that the steel industry plans to reduce its capital spending in 1961 to a figure a little under $1,400,000,000 a year.

Rumors for an additional plant on the west coast were prevalent during the year. Part of this was the result of some land purchases in the Bay area. Bethlehem Steel Co. purchased 575 acres close to their San Francisco plant, and United States Steel Corp.'s Columbia-Geneva Steel Div. bought about 130 acres adjacent to their present 1000-acre plant at Pittsburg, Calif.

It was reported that a small rolling mill might be built near Miami, Fla., to have an annual capacity of up to 90,000 tons of reinforcing bars and merchant shapes.

Another possible steel plant in the south would be built by Florida Steel Corp., Tampa, Fla., which has plans to build a mill on the outskirts of Charlotte, N. C., to produce reinforcing bars. Estimated cost would be about $3,300,000 and the plant would have an annual capacity of 51,000 tons. There would be an electric furnace operating on local scrap.

In October, 1960, The Colorado Fuel and Iron Corp. sold their plant at Claymont, Del., to the Phoenix Steel Corp. The Claymont plant, with a rated ingot capacity of 560,000 tons, is three miles away from Phoenix's Chester blast furnace, thus providing possibilities for integrated steelmaking. The Claymont plant has seven open hearth furnaces, two plate mills and an electric-weld mill for large diameter pipe, plus fabricating facilities.

New tinplate cuts can weight almost in half and offers marked savings to the canmaker.

Late in the year, the Phoenix Steel Corp. announced that it will close its plate mill at Harrisburg, Pa., which had an annual plate rolling capacity of 791,000 tons.

There seems to be a growing interest in the steel industry in setting up operations abroad. Two companies, Allegheny Ludlum and Crucible Steel, announced major ventures into European projects. Allegheny Ludlum will form a company with two Belgium concerns to make and sell specialty steels in the European and world markets. They plan to build a stainless specialty plant in Belgium at a cost of over $10,000,000, which will start production in 1962.

In 1960 Crucible Steel bought a 75 per cent interest in an Italian specialty steel producer who is building a new mill in Milan, Italy, in which Crucible Steel will invest about $2,400,000.

Also, Youngstown Sheet and Tube Co. reported a possibility of investing in European steel manufacturing. It was reported that Youngstown might join a group of French and Belgium steel companies to build a fully integrated plant on the Ghent Canal in Belgium.

In order to find ways of making better steel products, the steel industry has been constructing new research facilities. National Steel Corp. broke ground in April for a large research and development center at Weirton. At the site they are also going to build a new office building. Bethlehem Steel Co. also has a large research

center under construction. United States Steel Corp. opened their new electromechanical laboratories in May. These laboratories are dedicated to the development of control systems for new and existing processes.

One of the most interesting battles which the steel industry faces is the competition being given by aluminum. As a result of this competition, United States Steel Corp. brought out a new tinplate at a price about 15 per cent below conventional tinplate. Also, despite higher costs and wage increases, the steel industry held the price of conventional tinplate at the old levels. The aluminum industry has also cut price on aluminum for cans, and has come up with experimental cans that are lighter than the conventional aluminum can.

For the convenience of the consumer, some of the aluminum cans have been made with a special top which does not require a can opener. One major disadvantage of aluminum is that it cannot be soldered by current production methods and must instead be cemented. The cementing will not stand the temperatures needed to heat-treat some canned foods.

At the end of the year, a number of canmakers indicated that aluminum cans would get 25 per cent or more of the citrus packing business in 1960–1961 season. Plastics and glass are also giving competition in a number of can applications.

A newly developed aluminum drill pipe which was tested in the field this year was reported to be satisfactory. Admittedly, the aluminum pipe will cost more than steel pipe but it is claimed lightness and corrosion resistance may make it economical.

Another aluminum pipe application is a natural gas line. Primary advantages claimed were corrosion resistance, both above and below ground, and better gas flow because of smooth surface. Elimination of maintenance painting is also an economy.

One product for which steel might find a good market would be a galvanized sheet which would be galvanized on the one side and free from coatings or defects on the other side. Such a product is being used in automobile bodies.

One approach has been through the use of differentially coated galvanized stock. In the process, part of the zinc coating on the one side is removed by wiping or brushing as the sheet comes out of the coating tank. This product has been used in the 1960 Falcons. A number of plants are experimenting with various other approaches to differential galvanizing.

Another item which will help steel business is a new one-coat porcelain enameling steel. This steel does away with the ground coat and, as a result, enameling cost can be reduced some 15 to 30 per cent. This steel contains virtually no carbon and thus forms a panel which is free from distortion, boiling and fish scaling. Several producers are entering the field.

For appearance and styling, an American steel company has developed stainless steel in colors. Several shades are on the market. First commercial uses are for architectural panels for curtain-wall buildings.

A number of steels have been developed which save weight and maintain strength. In most cases these are steels with a higher minimum yield point. They may be divided into two groups: high strength low alloy steels with minimum yields up to 50,000 psi, and heat treated constructional alloy steels with minimum yields of 65,000 to 100,000 psi. In addition some of these steels have the desirable qualities of corrosion and wear resistance, which reduce minimum thicknesses which may be necessary.

ASTM gave specification approval to A-36 which has a minimum yield of 36,000 psi, with control of carbon and manganese for better weldability. Cost increase over A-7 is minor.

Another advance is a stronger structural steel developed in Canada which has also received official specification approval by the Canadian Standards Association. This steel is known as CSA-G40.8. It has a minimum yield strength of 40,000 psi for thicknesses up to $\frac{5}{8}$ in., and was originally developed to resist brittle failure, particularly at low temperatures, in steel structures. Good weldability is also claimed for the steel.

Significant savings in the fabrication of steel structures are reported for a new T-1 type A steel which is available in plates and bars from $\frac{3}{16}$ to 1-in. thick.

On January 4, 1960, the 11 companies of the Steel Companies Coordinating Committee and the United Steelworkers of America signed a 3-year contract which settled issues brought up by the strike ended on November 7, 1959. The agreement was complicated and involved a number of factors not at first fully understood. The agreement tied in cost of living raises with the amount that was paid into insurance costs. As a result, since some insurance costs ran higher than expected originally, some wage increases did not go through. In addition, when the wage agreement was settled the major cutbacks which occurred at the end of the year

A marked expansion in research facilities by steel producers is under way. View shows Monroeville, Pa., laboratory of U. S. Steel, who this year completed their electromechanical building, shown at the right.

were not anticipated. The large drawdown on supplementary unemployment benefits necessitated in a number of cases cutting down the SUB payments, with the unhappy result, that some of the senior workers being laid off at the end of the year were receiving less than those with less seniority who had been laid off earlier did when they were first laid off.

The joint committees, composed of steelworkers and management which were established apparently made little progress during the year. They were to develop procedures for improving labor management relations and also to study the various work rule problems.

On December 1, 1960, the steel industries had to hike wages in accordance with the requirements of the new contract. Market conditions being slow, there were no signs that price increases were to be put into effect. As a result, a cost squeeze tightened markedly and is showing up in earning reports.

The additional cost added by the increases varies with the estimator but would probably average around $15 a ton for the three raises which will go into effect under the contract.

Total 1960 payroll for wage and salaried employees set a new record of $3,900,000,000. The average number of wage and salaried employees was around 576,000. The average payroll cost per hr worked by hourly employees was estimated at $3.36, not including an estimated 48¢ per hr for employee fringe benefit costs. Wage earners averaged about 36 hr per week.

Automation of the steel industry has set up a need for higher skills and more white collar workers. In 1959 more than 22 per cent of iron and steel industry's work force were salaried, compared with only ten per cent 25 years before. On an over-all basis the steel industry has been adding to its ranks of salaried workers at an average rate of nearly 3000 per year.

Steelworkers met at their annual convention in September in Atlantic City. No definite programs were established but the tone of the convention indicated that the steelworkers were concerned about job security and will seriously fight for this in the future. One item will be major revisions of the supplementary unemployment benefits setup. Another demand which was discussed was the 32-hr week.

The earnings report for the various steel companies indicated that the breakeven points of the companies prior to the last steel raise were somewhat below 50 per cent of capacity. On the other hand, despite the fact that the companies showed a profit, few earned their dividends in the last half of the year.

An interesting comparison shows that for the first six months of 1960, employment cost per ingot ton totaled $54.98 compared with $32.54 in 1950 and $17.42 in 1940.

Among technical developments, the more important (in the steel industry) point to beneficiation and upgrading of ore, the use of oxygen in both open hearth and converter steelmaking (with the emphasis on oxygen converters for new plants and the use of oxygen to increase production in existing open hearths), and the use of computers all through the steel plant to increase production, obtain better data and records, and improve quality. All of these advances have as their major goals higher quality and improved economy.

DETAILED EXPANSION

Throughout 1960, the steel industry continued on a major construction and modernization program. Much of this was continued or carried over from the previous year; much was done as a part of long-term development programs.

(*Please turn to page 137*)

PARTIAL LISTING OF ANNOUNCED EXPANSION PLANS
(c) Denotes Completion in 1960

Company and plant	Cost	Additional ingot capacity, tons	Steelmaking facilities	Additional iron capacity, tons	Ore preparation	Hot mills	Cold mills	Finishing facilities	Heating furnaces and pits	Miscellaneous
Acme Steel Co., Riverdale, Ill.	$ 11,500,000	.....	.....	.....	.....	Hot strip mill revamp (c)	.....	.....	.....	.....
Alan Wood Steel Co., Conshohocken, Pa.	33,000,000	.....	Mold yard crane—increase capacity. (c) Additional narrow gage trackage, open hearth. (c) Alterations No. 1 pouring platform. (c)	Fuel-air ratio control, No. 2 stoves. Dustcatcher, No. 3 furnace. Sinter plant alterations. (c)	.....	40 × 96-In., blooming mill. 110-In. plate mill	Automatic tension control—tandem mill. (c)	6-In. waste acid pipe line.(c) Additional annealing furnaces and bases. (c)	Combination gas and oil burner furnace	Physical testing facilities testing laboratory. Instrumentation coke gas. (c)
Allegheny Ludlum Steel Corp., Brackenridge, Pa.	40,000,000	.....	Expansion, existing open hearth furnaces (improved technology)	.....	.....	.....	.....	.....	.....	New river-water intake system. (c)
Research Center, Brackenridge, Pa.	.....	.....	.....	.....	.....	.....	.....	.....	.....	Equipping two major additions with pilot-size steel processing and other research facilities
Bagdad, Pa.	.....	.....	.....	.....	.....	.....	.....	Continuous silicon normalizing line. (c)	.....	Major new plant addition
West Leechburg, Pa.	.....	.....	.....	.....	.....	.....	.....	Continuous electric furnace for bright-annealing stainless strip. (c)	.....	.....

PARTIAL LISTING OF ANNOUNCED EXPANSION PLANS (CONTINUED)

Company and plant	Cost	Additional ingot capacity, tons	Steelmaking facilities	Additional iron capacity, tons	Ore preparation	Hot mills	Cold mills	Finishing facilities	Heating furnaces and pits	Miscellaneous
Watervliet, N. Y.	.....	.....	50-In., diameter furnace for consumable electrode vacuum melting	.....	.....	.....	.....	.....	.....	.....
Wallingford Steel Co., Wallingford, Conn.	.....	.....	.....	.....	.....	.....	.....	Continuous electric furnace for bright annealing stainless strip. (c) Equipment for automatic surface grinding of stainless steel strip. (c)	.....	.....
Armco Steel Corp., Ashland, Ky.	150,000,000	.....	.....	.....	.....	.....	.....	Additional processing and finishing facilities	.....	.....
Baltimore, Md.	.....	.....	.....	.....	.....	.....	.....	.....	.....	Additional bar warehouse
Butler, Pa.	.....	.....	.....	.....	.....	.....	Sendzimir mill	Annealing and pickling line	.....	Rewind line, coi grinder line. Service buildings
Middletown, Ohio	.....	.....	.....	.....	.....	Spiral weld pipe mill	.....	72-In. continuous galvanizing line. Open coil annealing facilities	.....	Addition to research laboratories. Addition to fabricating plant No. 2
Zanesville, Ohio	.....	.....	.....	.....	.....	.....	.....	Continuous annealing line	.....	.....
Sheffield Div., Kansas City, Kansas	.....	.....	No. 3 electric furnace	.....	.....	.....	.....	Bar joist plant	.....	.....
Houston, Texas	.....	.....	Open hearth improvements	.....	.....	Combination slabbing and 160-in. plate mill. No. 2 cooling bed	.....	Plate heat treating line	.....	Ore dock
National Supply Co., Ambridge, Pa.	.....	.....	.....	.....	.....	Combination electric weld and continuous weld mill	.....	.....	.....	.....
Atlantic Steel Co., Atlanta, Ga.	.....	.....	.....	.....	.....	.....	.....	.....	Billet heating furnace 30 tons per hr., 2-zone dual fuel burners, recuperator	Direct reading spectrograph. (c) Power distribution system. (c) 2 chain link fence machines. (c) 3-No. 3 glader nail machines. (c)
Bethlehem Steel Co., Bethlehem, Pa.	.....	.....	Expanded vacuum casting unit	Enlarge one blast furnace. (c)	Sinter plant additions	.....	.....	.....	.....	Research laboratories. North Side office building. Printery. (c)
Steelton, Pa.	.....	.....	.....	.....	.....	11-In., 17-stand bar mill. (c)	.....	Expand weld pipe line. (c)	.....	Re-bar fabricating shop. (c)
Lebanon, Pa.	.....	.....	.....	.....	.....	.....	.....	.....	.....	Automatic bolt making line. (c)
Sparrows Point, Md.	.....	800,000	7 Open hearth furnaces converted to oxygen use	.....	.....	Modernize 56-in., hot strip mill	.....	Modernize flange mill	New soaking pits	Rebuild coke oven battery
Lackawanna, N. Y.	.....	400,000	9 Open hearth furnaces converted to oxygen use	Blast furnace turboblower	New ore bridge. Extension to ore storage yard. (c)	Three down-coilers. 40 x 90-In., slabbing mill	Beam guard rail forming line. Welded joist line. New slab form line	New open coil annealing facilities	Soaking pits	New coke oven battery. Water pumping station
Johnstown, Pa.	.....	.....	.....	Ferro manganese improvement	Sinter cooler. (c)	134-In., plate mill shearing equipment. (c)	.....	.....	.....	Flue dust recovery system. (c) Rebuild two coke oven batteries
Morgantown, Pa.	.....	.....	.....	.....	.....	.....	.....	.....	.....	Pellet plant Grace Mine.
San Francisco, Calif.	.....	.....	.....	.....	.....	.....	.....	.....	.....	New office building
Seattle, Wash.	.....	.....	.....	.....	.....	.....	.....	.....	.....	New office building
Los Angeles, Calif.	.....	.....	.....	H-iron plant. (c)	.....	.....	.....	.....	.....	.....
Border Steel Rolling Mill, Inc., El Paso, Texas	.....	.....	12-Ft electric furnace	.....	.....	8-Stand bar and rod mill	.....	.....	.....	.....
Calstrip Steel Corp., Los Angeles, Calif.	175,000	.....	.....	.....	.....	.....	2-High temper mill	.....	.....	.....
	40,000	.....	.....	.....	.....	.....	.....	Strip leveler and cut to length	.....	.....
	40,000	.....	.....	.....	.....	.....	.....	Precision strip slitter	.....	.....

Company and plant	Cost	Additional ingot capacity, tons	Steelmaking facilities	Additional iron capacity, tons	Ore preparation	Hot mills	Cold mills	Finishing facilities	Heating furnaces and pits	Miscellaneous
The Carpenter Steel Co.	$ 6,500,000									
Reading, Pa.	.....	.....	.....	.....	.....	10-In., hot mill improvements	.....	Bar shaving machine. Copper coating facilities. (c) Cutting machine. (c)	Roller hearth heat treating furnace. (c) Two car type annealing furnace. 3-Door heating furnace. (c) Strand annealing furnace. (c) Bright annealing furnace	Expansion of three branch warehouses. Stress rupture testing equip (c) Diesel locomotive. (c Milling machine. (c)
Alloy Tube Div., Union, N. J.	.....	.....	.....	.....	.....	.....	.....	Finned tubing equip. (c) New stainless tube mill. (c)	Bright annealing furnace. (c)	Finished stock warehouse
Webb Wire Div., New Brunswick, N. J.	.....	.....	.....	.....	.....	.....	.....	.....	.....	Land, buildings and necessary equipment for new plant site
Carpenter Steel of New England Inc., Bridgeport, Conn.	.....	.....	Melt shop revisions	.....	.....	.....	.....	3 Bar straighteners. (c) Bar turner. (c) Billet preparation. Renovate C. F. Dept. building.	5 Annealing furnaces. (c)	Cleaning dept. building and equipment. Crane. (c)
The Colorado Fuel & Iron Corp. Pueblo Plant	$ 22,000,000 (16,600,000)	(600,000) No net increase	Two 100-ton oxygen converters	.....	.....	25-In., mill improvements. (c) 14-In., mill improvements. (c)	.....	Wire mill additions and improvements	.....	Power distribution system
Oakland and South San Francisco	.....	.....	.....	.....	.....	.....	.....	Wire fabricating equipment and improvements	.....	.....
Buffalo, N. Y.	.....	.....	.....	.....	.....	.....	.....	Additional wire mill equipment	.....	.....
Palmer, Mass.	.....	.....	.....	.....	.....	.....	.....	Additional wire mill equipment and improvements		
John A. Roebling's Sons Div., Trenton, N. J.	.....	.....	.....	.....	.....	.....	.....	Additional wire mill equipment and improvements	.....	.....
Continental Steel Corp., Kokomo Ind.	$ 2,396,000	.....	Revamping one open hearth furnace	.....	.....	.....	.....	High-carbon wire drawing and tempering bldgs. and equipment. Revamping chain link fence galvanizing bldg. and equipment.	New row soaking pits. (c)	.....
Copperweld Steel Co. Aristoloy Steel Div., Warren, Ohio	$ 5,300,000	.....	Consumable electrode vacuum melting furnace	.....	.....	20-In. cooling bed. 18-In. mill roughing stand.	.....	Continuous bar drawing equipment	One 3-hole soaking pit. (c) 3 Continuous annealing furnaces	Testing and material handling facilities
Wire and Cable Div., Glassport, Pa.	6,000,000	.....	.....	.....	.....	.....	.....	Aluminum covered steel wire and rod production	.....	.....
Superior Steel Div., Carnegie, Pa.	2,400,000	.....	.....	.....	.....	.....	30-In. 4-high breakdown mill improvements	Slitting facilities. Revamp scouring line	Annealing and pickling line modernization. (c)	Material handling facilities. (c) Additional electrical equipment. (c)
Ohio Seamless Tube Div., Shelby, Ohio	2,100,000	.....	.....	.....	.....	.....	.....	Electric-weld tube equipment modernization. Two electric-weld tube-making lines	.....	.....
Crucible Steel Co. of America	$ 23,000,000									
Midland, Pa.	.....	.....	Vacuum degassing unit. (c)	.....	.....	Hot strip mill. (c) Electrify 46-in. bloomer. (c)	.....	.....	.....	.....
Detroit Steel Corp., Portsmouth Div., Portsmouth, Ohio	$ 13,000,000 ($5,500,000 in 1960)	400,000	Enlarge 3 open hearth furnaces. Convert all 5 furnaces to all-basic brick. Install oxygen jets	.....	.....	.....	.....	Additional pickling facilities	3 Soaking pits. Single stack annealing equipment. (6 furnaces, 18 bases)	New water plant and distribution system. New electric power distribution system
Eastern Stainless Steel Corp., Baltimore, Md.	$ 200,000	.....	.....	.....	.....	84-In. wide plate mill revamp.	.....	.....	12-tons per hr, 2100 F, controlled atmosphere.	.....

PARTIAL LISTING OF ANNOUNCED EXPANSION PLANS (CONTINUED)

Company and plant	Cost	Additional ingot capacity, tons	Steelmaking facilities	Additional iron capacity, tons	Ore preparation	Hot mills	Cold mills	Finishing facilities	Heating furnaces and pits	Miscellaneous
Edgewater Steel Co., Oakmont, Pa.	$ 1,215,000	.....	.....	.....	.....	Ring rolling facility including auxiliary equip-	.....	Additional finishing equipment	.....	Mill water improvement. Electric power distribution system
Ford Motor Co., Rouge Plant, Dearborn, Mich.	.....	.....	280-Ton per day oxygen plant	Blast furnace modernization	.....	Revamp 66-in. hot strip mill	66-In. 4-stand tandem mill	.....	4 Soaking pits. Slab heating furnace. Additional annealing	.....
Granite City Steel Co., Granite City, Ill.	.....	300,000	One 350-ton ladle crane. (c)	Replaced "B" blast furnace with 1800-ton unit. Off-site 170-ton oxygen generator	.....	.....	44-In. sendzimir mill.	Electrolytic tinning line. 42-In., continuous annealing line. Continuous galvanizing line	Extended steelmaking building. (c)	Office building. (c) Additional buildings at N. Plant. 71,000 sq ft floor space. (c) Power house at blast furnace. (c) Add "C" battery 61 coke ovens
Inland Steel Co., Indiana Harbor, Ind.	$ 70,000,000 (In 1960 overall)	.....	Conversion of 17 open hearth furnaces to basic brick construction. Installation of oxygen lances in 8 furnaces	Reline one blast furnace. (c) New turboblower. (c) Conversion to high top pressure operation. One blast furnace. (c) Blast furnace modernization. 7 furnaces (stove dome temperature controls and automatic coke charging and watering equipment)	.....	44-In., hot strip coilers. (c) Wide flange structural mill improvement. (c)	54-In. 2-stand temper mill. (c)	Coil inspection and conditioning line in tin mill. 62-In. decoil and shear line. Electrolytic tinning line. (c) Continuous cleaning and annealing line. (c) Continuous galvanizing and aluminizing line. Conversion of electrolytic tinning line for coiling	Open coil annealing facilities. Two 28-in., structural mill reheating furnaces. (c) One four-stack annealing furnace	Coal handling facilities. Additional galvanize shipping and warehouse facilities. (c) New ore carrier. (c)
Chicago Heights, Ill.	.....	.....	.....	.....	.....	Revamp rail reroll mills. (c)	.....	.....	Reheating furnace. (c)	.....
Interlake Iron Corp., Chicago, Ill.	.....	.....	.....	8-Ft-3 in. wide sinter line	.....	.....	.....	.....	.....	.....
International Harvester Co., Wisconsin Steel Div., Chicago, Ill.	$ 12,000,000	.....	.....	.....	.....	.....	.....	.....	.....	.....
	1,250,000	.....	.....	.....	.....	14-stand continuous merchant mill	.....	.....	Soaking pits. (c)	.....
Jessop Steel Corp., Washington, Pa.	$ 2,000,000	.....	Improve electric furnaces	.....	.....	.....	Miscellaneous improvements.	.....	.....	.....
Jones & Laughlin Steel Corp. Aliquippa Works	$ 184,000,000	.....	.....	.....	Sinter plant. (c)	.....	.....	Electrolytic tin line. Tin coil handling and shipping facilities.	Continuous annealing line. (c)	Coal crushing, screening and blending. (c)
Pittsburgh Works	.....	.....	Improvements to open hearth including dust and smoke elimination	.....	Sinter plant improvements. (c)	.....	.....	Heat treating facilities for bar and coil stock. (c)	.....	2 Coke batteries 59 ovens each (c) 1 Coke battery 118 ovens. Expanded by-product facilities. Coal crushing, screening and blending. (c)
Cleveland Works	.....	.....	2 Basic oxygen furnaces	.....	.....	.....	.....	.....	4 Soaking pits. (c)	.....
Stainless & Strip Div., Detroit Plant	.....	.....	.....	.....	.....	.....	.....	Additional finishing and warehousing	.....	.....
Raw Materials Div., Star Lake, N. Y.	.....	.....	.....	.....	Improvements to sintering facilities. (c)	.....	.....	.....	.....	.....
Warehouse Div.	.....	.....	.....	.....	.....	.....	.....	48-In., slitting line. (c)	.....	New warehouse facilities. (c)
Kaiser Steel Corp. Fontana, Calif.	.....	.....	.....	.....	Limestone crushing facilities. Improvements in sintering facilities	.....	.....	96-In. shear line. (c)	6 Soaking pits. (c)	.....
Eagle Mountain, Calif.	.....	.....	.....	.....	New ore blending, primary and secondary crushing, load-out facilities	.....	.....	.....	.....	.....

Company and plant	Cost	Additional ingot capacity, tons	Steelmaking facilities	Additional iron capacity, tons	Ore preparation	Hot mills	Cold mills	Finishing facilities	Heating furnaces and pits	Miscellaneous
Keystone Steel & Wire Co., Peoria, Ill.	.....	120,000	1 Open hearth furnace. (c)	.....	.....	.....	.....	.....	.....	.....
	$ 1,500,000	.....	.....	.....	.....	Blooming mill manipulator. (c)	.....	.....	.....	.....
	1,780,000	.....	.....	.....	.....	.....	.....	Welded fabric building and equipment. (c)	.....	.....
	170,000	.....	.....	.....	.....	.....	.....	.....	.....	Open hearth laboratories. (c)
	190,000	.....	.....	.....	.....	.....	.....	Netting extension and equipment. (c)	.....	.....
	340,000	.....	.....	.....	.....	.....	.....	Nail cleaning and packaging. (c)	.....	.....
	115,000	.....	.....	.....	.....	.....	.....	.....	.....	Rod testing building and equipment. (c)
Lone Star Steel Co., Daingerfield, Texas	.....	.....	.....	.....	.....	Spiral weld pipe mill	.....	.....	.....	.....
Lukens Steel Co., Coatesville, Pa.	$ 1,200,000	.....	Open hearth improvements including Isley stack, extended hearth and 2 basic roofs. (c)	.....	.....	.....	.....	Additional slab grinding and conditioning area. New slab grinding machine. (c)	.....	Additional waste water treatment facilities. Modernization of boiler facilities and steam distribution in one plant area
McLouth Steel Corp., Trenton, Mich.	$ 11,000,000	.....	110-Ton oxygen process vessel. (c)	.....	200-Ton sintering plant.	.....	.....	.....	.....	.....
	2,000,000	.....	.....	.....	.....	Hot mill control system	.....	.....	.....	.....
National Steel Corp.	$ 300,000,000	.....	.....	.....	.....	.....	.....	.....	.....	Research laboratory.
Great Lakes Steel Corp., Ecorse, Mich.	.....	500,000	Two basic oxygen furnaces	.....	.....	80-In. hot strip mill	.....	.....	Four 250-ton/hr slab heating furnaces	500-Ton per day oxygen plant
Midwest Steel Corp., Portage, Ind.	.....	.....	.....	.....	.....	.....	5-Stand, 52-in. tandem mill. 2- Stand 52-in. temper mill. Single stand sheet temper mill	80-In. electrolytic tinplate line. 80-In. pickle line. 48-In. continuous galvanizing line. 48-In. shearing line	45-In. continuous annealing line	.....
Weirton Steel Co., Weirton, W. Va.	.....	.....	.....	.....	.....	.....	.....	.....	.....	General office building
Northwestern Steel and Wire Co., Sterling, Ill.	$ 1,600,000	.....	.....	.....	.....	.....	.....	Additional finishing line. 12-In. merchant bar mill	.....	.....
	1,300,000	.....	.....	.....	.....	.....	.....	.....	.....	Additional building facilities 20-In. structural and plate mill and 12-in. merchant bar mill
H. K. Porter Co., Inc. Connors Steel Div., Connors Works, Birmingham, Ala.	$ 40,300	.....	Improvements. (c)	.....	.....	.....	.....	.....	.....	Miscellaneous. (c)
West Virginia Works, Huntington, W. Va.	525,000	.....	Electric furnace additions	.....	.....	.....	.....	.....	.....	.....
Republic Steel Corp. Buffalo, N. Y.	$ 375,000,000	.....	.....	.....	.....	.....	.....	.....	Enlarge soaking pit capacity. (c)	.....
Canton, Ohio	.....	.....	.....	.....	.....	8-In. bar mil	.....	Heat treating and finishing facilities for coiled and cut length bars	.....	.....
Chicago, Ill.	.....	.....	.....	.....	.....	.....	.....	.....	Heat treating and annealing facilities for coiled and cut length bars. (c) Heat treating, sizing and related facilities for casing. (c)	.....
Gadsden, Ala.	.....	.....	.....	.....	Sinter plant. (c)	134-In., 4-high reversing plate mill. (c)	Additional stand-tandem mill	.....	Enlarge soaking pit capacity. (c) Additional annealing facilities	Coke oven battery and coal chemical recovery plant
Massillon, Ohio	.....	.....	.....	.....	.....	.....	.....	Facilities for processing stainless flat roll including new annealing and cutting equipment	.....	.....
Niles, Ohio	.....	.....	.....	.....	.....	.....	.....	.....	Additional annealing capacity	.....

PARTIAL LISTING OF ANNOUNCED EXPANSION PLANS (CONTINUED)

Company and plant	Cost	Additional ingot capacity, tons	Steelmaking facilities	Additional iron capacity, tons	Ore preparation	Hot mills	Cold mills	Finishing facilities	Heating furnaces and pits	Miscellaneous
(Cont.) Republic Steel Corp. Warren, Ohio	.....	.....	.....	.....	.....	56-In. semi-continuous hot strip mill.	2 Temper mills.	48-In. continuous hot dip galvanizing line. Continuous pickler. 2 Cutting lines	Additional annealing capacity	.....
Youngstown, Ohio	.....	.....	.....	.....	.....	.....	.....	2 Plastic pipe coating lines. (one c)	.....	Coke oven battery. (c)
Timken Roller Bearing Co., Steel and Tube Div., Gambrinus Plant, Gambrinus, Ohio	$ 4,500,000	.....	.....	.....	.....	Seamless tube mill. (c)	.....	.....	.....	Air cleaning equipment for electric furnaces
United States Steel Corp.										
Central Operations, Clairton Works, Clairton, Pa.	.....	.....	.....	.....	.....	.....	.....	.....	.....	Steam generator. (c) Tar distilling facilities. (c)
Duquesne Works, Duquesne, Pa.	.....	.....	.....	28-Ft blast furnace.	.....	.....	.....	.....	.....	.....
Edgar Thomson Works, Braddock, Pa.	.....	.....	.....	.....	.....	.....	.....	.....	6 Soaking pits. (c)	.....
Fairless Works, Fairless Hills, Pa.	.....	.....	Enlarge 9 open hearth furnaces. (c)	.....	Sinter line. (c)	.....	.....	Electrolytic tinning line. (c) Annealing line. (c)	16 Soaking pits. (c)	.....
Gary Sheet & Tin, Gary, Ind.	.....	.....	.....	.....	.....	.....	.....	Continuous annealing line. (c) Temper mill. Sheet coating line	.....	.....
Gary Steel Works, Gary, Ind.	.....	.....	.....	.....	.....	Improve 10-in. bar mill. (c) $160\frac{9}{210}$-In. plate mill	.....	.....	.....	.....
Homestead Works, Munhall, Pa.	.....	.....	Improve open hearths. (c)	.....	.....	Improve 160-in. plate mill	.....	Heat treat furnaces for forgings. (c) Plate heat treat line	3 Heating furnaces. (c)	.....
Carrie Furnaces, Rankin, Pa.	.....	.....	.....	Enlarge No. 4 blast furnace. (c)	.....	.....	.....	.....	.....	.....
Irvin Works, Dravosburg, Pa.	.....	.....	.....	.....	.....	.....	.....	Continuous annealing line. Open coil annealing facilities	.....	.....
Research, Universal, Pa.	.....	.....	.....	.....	.....	.....	.....	.....	.....	Experimental blast furnace
Columbia-Geneva Steel Div., Ore Mines, Atlantic City, Wyo.	.....	.....	.....	.....	Pellet plant	.....	.....	.....	.....	.....
Geneva Works, Geneva, Utah	.....	.....	.....	Enlarge blast furnace	.....	.....	.....	.....	.....	.....
Pittsburg Works, Pittsburg, Calif.	.....	.....	.....	.....	.....	.....	.....	Continuous annealing line. (c)	.....	.....
National Tube Div., Lorain Works, Lorain, Ohio	.....	.....	.....	Enlarge blast furnace	.....	.....	.....	Continuous buttweld pipe mill. (c)	.....	.....
Tennessee Coal & Iron Div., Fairfield Works, Fairfield, Ala.	.....	.....	.....	.....	Sinter line	.....	6-Stand, 52-in. tandem mill. Improve plate mill	Temper mill. (c) Continuous annealing line. (c) Continuous 54-in. pickle line	.....	.....
Universal Cyclops Steel Corp.	$ 36,000,000									
Empire-Reeves Div., Coshocton, Ohio	.....	.....	.....	.....	.....	.....	30-In. reversing mill	.....	.....	.....
Mansfield, Ohio	.....	.....	.....	.....	.....	Improve 54-in. hot strip mill	.....	.....	.....	.....
Wheeling Steel Corp.	$ 16,700,000									
Steubenville Works, Steubenville, Ohio	.....	.....	Oxygen generating site. (c)	Enlarge blast furnace. (c) Enlarge stove. (c) Blast furnace blower. (c)	.....	.....	.....	Relocate sheet and strip equipment. (c)	One row pits. (c)	Relocate RR tracks. Revamp one battery coke ovens
Yorkville, Works, Yorkville, Ohio	.....	.....	.....	.....	.....	.....	.....	Revamp tin line. (c)	.....	Boiler equipment. (c)

Company and plant	Cost	Additional ingot capacity, tons	Steelmaking facilities	Additional iron capacity, tons	Ore preparation	Hot mills	Cold mills	Finishing facilities	Heating furnaces and pits	Miscellaneous
The Youngstown Sheet and Tube Co.	$ 150,000,000									
Chicago District, Indiana Harbor Works, East Chicago, Ind.	.....	.....	.....	.....	Ore yard and dock extension	.....	52-In. 6-stand tandem mill	Continuous annealing line. Continuous sheet galvanizing line. Pickle line alterations. Additional seamless finishing equipment. Merchant mill pickling equipment	Merchant mill annealing furnace.	87-Oven coke battery.
Youngstown District, Campbell Works	.....	.....	.....	.....	.....	79-In. hot strip mill revamp	Alterations for large coils	Pickle line alterations	Cold strip mill annealing furnace	Coke plant. Benzol light oil purification plant
Brier Hill Works	.....	.....	.....	.....	.....	Blooming mill-pit crane and slab handling facilities	.....	Electric weld tube mill coil preparation and shear line	.....	Blast furnace trestle and bins modernization
Partial totals	$1,496,576,300	2,520,000								

(*Continued from page 131*)

In some cases there was some stretch-out, sometimes due to a change in the urgency or need for the new facilities.

Most of the programs emphasize building facilities either for more economic operation or for a better quality (both of these items are obtained by the same program in many cases) or toward rounding out products or facilities.

The preceding expansion table is based on information primarily from steel company reports, official company releases, financial statements, discussions, etc. It is only a partial table with some companies listing only their major programs, one company lists projects only over $5,000,000 each, and in some cases the cost figures have been omitted.

Where possible, the items and the costs have been allocated against a particular plant location. In some other cases only the over-all costs are given. When figures are given in parentheses, they are a subtotal and included in some other over-all figure. One difficulty in setting up such a table is that some of the programs are carried over into periods longer than the year 1960 and it is difficult to assess the portion of the cost which pertains only to 1960. Since it is difficult to assess cost against a particular year, the figures indicated, in most cases, are the over-all program costs. In some other cases the dollar figure has been used only in the year of announcement and the following years are left blank, particularly if the carryover is minor.

This table has a subtotal for additional ingot capacity of about 2½ million tons. Actual increases will be undoubtedly higher because an analysis of the table shows that many of the improvements in steelmaking are for oxygen facilities which will increase capacity by amounts which are difficult to determine in advance. Also, in some cases, additional ingot capacity which is being installed will result in abandonment of older uneconomic facilities.

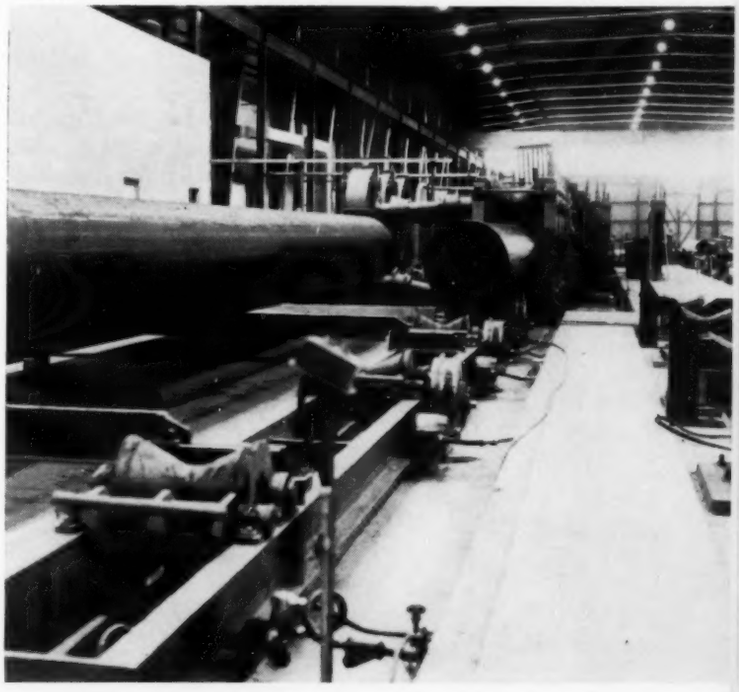
The partial total on the table of projects is 1½ billion dollars. There is at least an additional billion dollars on authorized programs by several companies whose figures are not listed in this table. The indications definitely are that for the next few years there will be major construction programs in the steel industry to complete the work already authorized, even though not a single additional dollar were to be authorized.

FOREIGN

World wide the steel industry is in a race to increase production capacity. Each country is trying to keep pace with or move ahead of other countries in developing its steel industry. According to the American Iron & Steel Institute, an estimated $5,000,000,000 was to be spent in 1960 for expansion and modernization by all countries combined. About one-third of this, or $1,600,000,000, was scheduled to be spent in the United States. This is slightly higher than the 29 per cent U. S. share of world output. It was estimated that Russia, which produced about 20 per cent of the world's steel in 1959, would probably spend at least $1,000,000,000 for iron and steel facilities this year. Japan also expected to spend over $500,000,000.

In some ways these figures in terms of dollars for

Big Inch Pipe Corp. started a new plant near Calgary, Canada, which can produce pipe up to 36-in. outside diameter.



expansion are not true comparisons because of the variations in the purchasing power of the dollar and artificial figures for converting currencies in various countries.

A tremendous increase in world-wide steelmaking capacity is expected in the next five years. Projected capacity to 1965 is estimated at about 535,000,000 tons. Of this, the Free World would have about 70 per cent. Some of the more important targets are India, 11,000,000 net tons; Japan, 35,000,000 tons; China, 25,000,000 tons; Russia, 97,000,000 tons; United Kingdom, 34,000,000 tons; West Germany, 42,000,000 tons.

According to an Economic Commission for Europe report, Africa's steelmaking capacity will increase more than 80 per cent in the next five years. That in the Middle East will go up 60 per cent; that in the Far East, about 140 per cent. Other increases are Latin America, 139 per cent; Russia, 50 per cent; Europe, 26 per cent; and North America, 23 per cent.

This world-wide expansion points to increased competition for world markets. In addition to capacity, steel quality is getting much attention with the installation of equipment to give products competitive with the best that any country has to offer.

Some trends throughout the world on technological developments are as follows: The oxygen converter process, with whatever modifications are required by local raw materials, is being installed extensively throughout the world. Other oxygen processes such as the Stora-Kaldo, and the rotor converter are also breaking into the picture. Foreign countries also are adopting the use of oxygen in the open hearth and in bessemer. Some applications of direct reduction are being installed abroad. Continuous casting, which has not made much headway in the United States, is being used in a number of installations throughout the rest of the world.

In the first six months of 1960, world steel production set a new record of 187,000,000 tons, eight per cent over the 1959 period. All major producing countries had increases with the exception of the United States, which was down five per cent for that period.

Canadian steel production for year totaled about 6,000,000 tons. Pig iron output totaled about 4,400,000 tons.

Extensive expansion is under way in Canada. Algoma Steel Corp. no sooner completed one program in 1959 than contracts were placed for another. These include a universal beam mill which will cost about $15,000,000 along with new continuous reheating furnaces for the rail and structural mill, and merchant mill. The universal beam mill is expected to be completed early in 1961 and will produce wide flange beams up to a maximum size of 24 in. Algoma is also relining and enlarging its No. 5 blast furnace to a 27-ft hearth diameter, which will increase iron capacity by about 100,000 tons annually.

Algoma is also building a 6-stand wide strip mill, as an extension to its bloom and plate mill, at an estimated cost of $30,000,000. This mill is scheduled for operation in 1963 and will produce hot rolled sheets and light plates to a maximum width of 96 in. The six main drive motors will have a total hp of 35,000.

Algoma is also modifying the bloom and plate mill which was completed in 1959 to permit rolling steel plate up to 112 in. wide for the manufacture of 36-in. diam pipe.

The Big Inch Pipe Corp. started operation of a continuous pipe mill at Calgary, Alberta. This mill is designed to fabricate large diameter line pipe in sizes from 18 to 36 in. outside diameter with a wall thickness of $\frac{3}{16}$ to $\frac{5}{8}$ in.

It is reported that new steelmaking facilities are being considered for northern Vancouver Island. Details of the project are not available.

At the Zapla Works in Jujuy Province, Argentina, a company owned by the Argentine Fabricaciones Militares is replacing two small charcoal blast furnaces built shortly after World War II with four larger units. Two of these have been completed and a third will start shortly. The program also includes steelmaking facilities consisting of three 15-ton converters, an alloy reduction furnace and two electric arc furnaces. It will be able to produce about 150,000 tons of ingots per year. Eventual capacity is to be 350,000 tons. Also on the program are a 3-high blooming and medium section mill to be delivered in 1961. To supply the blast furnaces with charcoal, a complete wood carbonization plant is also to be installed which can produce about 150,000 tons of charcoal per year from eucalyptus trees.

A decisive step in developing the Argentine steel industry has been the construction of the San Nicholas plant on the River Parana. This will be an integrated mill consisting of a by-product coke plant, a 28-ft blast furnace, four 250-ton open hearth furnaces, a 44-in. blooming and slabbing mill, a 66-in. hot strip mill, a 66-in. tandem cold mill, a galvanizing line, a continuous bar mill, and a rail and structural mill. Initial production is to be 700,000 tons of steel ingots per year. The San Nicholas plant is 125 miles northwest of Buenos Aires and 50 miles from Rosario. The blast furnaces were started in July, 1960, and the first open hearth is scheduled for operation in March, 1961. This plant is managed by a corporation known as Somisa, of which the government holds a major part of the stock.

Another project in Argentine is the erection of a new steel plant at Rosario to be known as the Altos Hornos de Parana project. Initial capacity of this will be 500,000 tons of ingots a year.

There are three important steelmaking projects which will increase steel production in Brazil. The first is the $200,000,000 project at the Companhia Siderurgica Paulista, or Cosipa, whose headquarters are at Sao Paulo, with the plant in Piacaguera. This is a private enterprise. This plant consists of a by-product coke plant, a 28-ft blast furnace; two 660-ton top-blown oxygen converters; soaking pits, a 44-in. slabbing mill; a 110-in., 4-high reversing plate mill; a 66-in., 5-stand hot strip mill; a 66-in., 3-stand tandem cold mill; temper mills and strip finishing lines. Initial production in 1963 will be 550,000 tons of steel ingots for automotive and shipbuilding.

Another plant under construction belongs to Usinas deMinas Gerais Co. (Usiminas). This mill is located at Ipatinga in the Rio Doce Valley, 20 miles east of Acesita. Production will be similar to Cosipa's. Facilities will include two 23-ft blast furnaces, a 120-in. plate mill, an 80-in. hot strip mill and a 66-in. tandem cold mill.

Forty per cent of the stock of this company belongs to a Japanese company, and the rest to the federal government of Brazil and to private investors. Production will be 550,000 tons of steel ingots in the first stage of production scheduled to start in 1963. Eventual capacity will be 2,000,000 tons. Much of the equipment is being purchased in Japan.

An interesting project in Brazil is the Companhia Ferro e Aco de Vitoria at Vitoria, in the state of Espirito Santo. This is a combination German and Brazilian company. The object is to produce bars and shapes starting at first with blooms from Usiminas and later adding a blast furnace and steelmaking shop.

The Acesita Iron and Steel Works, which is located some 350 miles north of Rio de Janeiro, in the Itabira region started up a 30-ton electric arc furnace. This plant consists of a charcoal blast furnace, steel melting shop and rolling mills.

A study by the Economic Commission for Latin America estimates that steel production of rolled products by 1965 will be as follows:

	Net tons per year
Argentine	2,600,000
Brazil	3,800,000
Colombia	300,000
Chile	560,000
Mexico	1,800,000
Peru	120,000
Venezuela	440,000
Other countries	240,000
Total	9,860,000

By 1975, projections indicate that steel production in Latin America will be 20,600,000 tons.

British plans for expansion indicate that steelmaking will be raised about 30 per cent within the next five years to over 33,000,000 net tons per year. This would require about $370,000,000 in 1960 and substantially more in 1961. This program includes the addition of two wide sheet mills and expansion of one of the three now in operation. At the present time an appreciable amount of wide sheet is shipped to England from the United States.

Four new blast furnaces came into operation in England during 1960. These included a 25-ft diam unit at South Durham Steel & Iron Co., Ltd., and a 31-ft diam unit at the Steel Co. of Wales, Ltd. Rolling mills built during the year include a new 45-in. slabbing mill at Appleby-Frodingham. Stewart and Lloyds started their 40 and 32-in. mills and the Patent Shaft Steel Works, Ltd., started a 96-in., 4-high plate mill.

An American company received an order for a universal slabbing mill, a 4-stand tandem cold mill, and a temper pass mill for Richard Thomas and Baldwins, Ltd., England. A wide semi-continuous hot mill is also being built. These mills are to be installed in the new Spencer Works, which will be a completely new integrated plant located at Llanwern, near Newport, Monmouthshire, scheduled to go into production late in 1961.

The Societe Anonyme Cockrill-Ougree at Tilleur, Belgium, ordered a 66-in., 4-high, 4-stand tandem cold mill, a 66-in., 4-high, single-stand skin pass mill and auxiliary equipment from a United States firm. Both mills are equipped with the latest type of coil handling equipment capable of delivering coils up to 72 in. in diameter, and 60,000 lb weight. The cold reduction mill will be designed to produce steel strip up to 60 in. wide and 0.008 in. thick. Both mills will operate at speeds up to 3600 fpm.

The first blast furnace at the Karaganda Metallurgical Works in Russia started producing pig iron on July 2.

Another Belgium mill was installed at the Societe Metallurgique Hainaut-Sambre S.A. at Couillet, Belgium in 1960. It is a section mill which can produce rounds, squares, flats, angles, channels and beams.

A new plate mill is to be installed at the Forges de Clabecq S.A. at Clabecq, Belgium. This will be a 112-in. heavy and medium plate mill plus auxiliary equipment.

Sollac, in France, ordered a 56-in., 5-stand tandem cold strip mill with 11 motors totaling 25,500 hp. They have also ordered a 57-in., 2-stand skin pass mill, and a 57-in., single-stand skin pass mill.

The Societe Dunkerquoise de Siderurgie or the Dunkirk Steel Works, ordered a heavy plate mill and complete finishing line equipment.

In Holland, a new integrated plant is under consideration for a site on Rotterdam's Europort harbor.

Iron production in Holland in 1960 totaled about 1,300,000 net tons and is expected to be 1,550,000 tons in 1961.

Present steel capacity is about 1,500,000 tons from six open hearths and two 60-ton converters at the Royal Netherland Blast Furnace and Steel Works (Hoogovens). A fifth blast furnace and sintering plant will raise capacity to 1,870,000 net tons late in 1961. When still additional iron capacity becomes available, it will be taken largely by three 100-ton oxygen converters which will replace the two 60-ton units, then steel capacity will be 2,100,000 net tons. This is in addition to 300,000 tons in two smaller firms.

N. V. Breedband, in the Netherlands ordered a 42-in., two-stand temper mill last year.

In Germany the August-Thyssen-Hutte A.G. is in the middle of a large expansion program at Duisburg, Hamborn. Their program includes two 165-ton top-blown converters which will raise monthly steel output to 380,000 net tons. A ninth blast furnace with a 29.5-ft hearth diameter was started. Other projects are pointed to modernization of mills and finishing facilities. A second semi-continuous hot wide strip mill plus slab rolling facilities are to be built. The company reports a sharp drop in manhours required per ton of steel. Before the war 12 manhours were needed; in 1959, the figure was down to seven manhours per net ton.

August-Thyssen is also involved with a number of other concerns in the development of several new ore deposits. One of the important ones is an ore body in the Western Sahara near Fort Gouraud. This project requires a railroad 400 miles long to bring ore to the nearest port, Port Etienne. The ore has 64 per cent iron and can be easily mined. Development costs are estimated at about $160,000,000, and annual deliveries of over 4,000,000 tons of ore are expected to start in 1964. This will be raised later to 6,000,000 tons per year.

Phoenix-Rheinrohr A.G. of Dusseldorf, West Germany, installed a 16-in. pipe mill.

A continuous wire rod mill is to be built at Klockner-Werke A.G. at Hutte Haspe. This unit, scheduled for delivery in the middle of 1962, will consist of 24 horizontal stands set up as an 8-stand roughing train, two intermediate trains each having four stands, and a finishing train with eight stands. All mill stands have roller bearings. Product will be $^{13}/_{64}$ to $^{1}/_{2}$-in. rod.

In Sweden, the Oxelosunds Jarnverks AB at Oxelosund, Sweden, put in a plate mill complete with auxiliary equipment which can produce up to about 440,000 net tons of plate annually. This is a 4-high, 144-in. reversing mill.

Heavy capital investment is being put into the Italian iron and steel industry. Some $50,000,000 was to be expended in 1960. Among the projects under way is one at Cornigliano where a third blast furnace is being built for a capacity of about 1900 net tons per day. Two existing blast furnaces will be modified to increase capacity from 1000 to 1300 net tons a day. Open hearths are to be enlarged to give 275 net tons per heat with oxygen.

The present development program at Cornigliano is estimated at almost $80,000,000. In 1962 capacity should be 1,650,000 net tons of pig iron and 1,800,000 tons of ingot steel.

Fiat has two large new projects at Vado. One of these will be an integrated plant which can produce 1,000,000 net tons of pig iron and 900,000 tons of steel annually. The other will be a plant with direct reduction of iron ore for an annual capacity of 330,000 tons.

Ilva near Bagnoli, near Naples, started a 1300-ton per day blast furnace in March, 1960.

Ilva at Piombino works has a blast furnace scheduled for completion in 1960 which will have a capacity of 1000 tons per day.

A government decision was made recently to build an integrated iron and steel plant in southern Italy. The Finsider group is planning this new plant at Taranto. It will have an initial capacity of about 2,000,000 net tons of steel and will produce hot flat products, including plates. Equipment will consist eventually of two 30-ft blast furnaces, an oxygen converter plant, and a mill for producing medium and large diameter welded pipe. Scheduled completion is the end of 1965. The pipe mill has been purchased from a subsidiary of U. S. Steel, and will start operation in the third quarter of 1961.

A new 80-in., 4-stand tandem cold mill is under construction for Cosider, S.P.A. Mura Di Santa Chiarai in Genoa, Italy. There is also an 80-in. temper mill under construction.

A 30.6-in. combination 3-high blooming and plate mill was installed in northern Spain. It can roll 2-ton ingots and slabs for plate up to three tons. The mill will produce plates 59 in. wide. It will also serve as a roughing mill for a proposed 21.6-in. medium section mill.

The Union Siderurgica Asturianas SA in Spain ordered a 15-stand combination rod and merchant mill.

A steel plant is under construction for Siderurgia Nacional at Seixal in Portugal, south of Lisbon. Initial capacity of the plant will be 250,000 tons per year. Initial plans include a blast furnace plant, sintering line, steel plant and rolling mill. The steel works will have a 35-ton electric arc furnace and a 30-ton oxygen blown converter. Rolling mills include a bloomer, a billet train, and a medium and continuous small-section mill.

A new steel plant is scheduled for Greece with a projected annual production of about 250,000 tons.

The Turkish plant Turkiye Demir ve Celik Isletmeteri which is near Karabuk is being expanded. The program has additional rolling mill facilities for rods, small sections and skelp. The mill will have an annual capacity of 200,000 tons of finished products.

Hungary's iron and steel industry is also expanding. The Hungarians have developed an integrated setup at Sztalinvaros, about 42 miles north of Budapest on the Danube River. This plant started up a hot rolling mill in 1960 which has an annual capacity of 550,000 net tons. A cold rolling mill is to be completed by the end of 1963. Plans call for an ouput of 1,100,000 net tons of rolled steel by 1975.

In the period 1961-1965, Hungary's second 5-year plan aims at building up national output to 1,800,000 net tons of iron and 2,650,000 net tons of steel.

Rumania has plans to build a new integrated iron and steel combine at Galati on the Danube River. The first stages of the plant are to go into operation by 1965. Target date for the whole job is 1970 when projected capacity is to be 4,000,000 tons of steel a year. The plant hopes to use new methods of producing coke from powdered coal. Newly discovered iron ore deposits can free them from dependence on outside sources.

In 1960, Russia's estimated steel production was 51,800,000 net tons of iron and 71,400,000 net tons of steel.

At the 1960 AISE Convention, a paper by two Russian steel officials presented a comprehensive review of the Russian steel industry. Some highlights of this paper follow:

Present planning for the Russian steel industry is covered by their 7-year plan of economic development from 1959 to 1965, providing for an increase in steel output by 1965 to 95,000,000 or 100,000,000 net tons, a growth of about 7.5 per cent every year. Facilities are being provided to add iron capacity of 26,000,000 to 33,000,000 tons, steelmaking capacity of 31,000,000 to 40,000,000 tons, and rolling capacity of 25,000,000 to 32,000,000 tons.

In 1960 under this plan, there should have been five large blast furnaces commissioned, ten large open hearth furnaces, three electric furnaces, six large rolling mills and eight coke oven batteries. They estimate that actual production growth will be ten per cent higher than the plan, and that by 1965, there will be 80,000,000 tons of iron capacity, 110,000,000 tons of steel capacity and 88,000,000 tons of rolling capacity.

In the Donbas or Stalino economic area, they estimate that by 1963, they will build two large blast furnaces, seven large open hearth furnaces, two converter shops and five rolling mills. More than one-half of all the blast furnaces in this economic area are operating with natural gas injection. Blast furnaces use oxygen-enriched blast. Blast temperatures exceed 1800 F.

In the Dniepropetrovsk economic area, all blast furnaces will be put on natural gas injection operation; some will have oxygen-enriched blast. High top pressure is being applied with pressures up to 22 psi, considerably higher than normal practice in the United States.

Prior to the current 7-year plan, the bulk of ferrous metal developments were located at what is known as the first and second metallurgical bases, which are in the Ukraine and in the Urals. The new plan provides a new metallurgical area with plants to be built east of the Urals in Siberia and Kazakhstan. In this metallurgical base there will be the present Kuznetsk combine, the Karaganda plant just put into operation, and the West Siberian Iron and Steel Works at present under construction. This plan also will see the commissioning of the Taishet plant in East Siberia. After 1965 another plant will be built in this area.

Also after 1965, the Russians are planning two other metallurgical bases at Kustanai and the Transbaikal. These will be located on the coking and coal and iron ore deposits of South Yakutia and the iron ore deposits at Kazakhstan.

The Russian steel plants in general will be designed so that each particular unit will specialize in certain types of products. Wire products may be in one plant, another plant may emphasize pipe making, another one flat products.

Extensive work, of course, is aimed at enlarging existing plants in Krivoy Rog, at Mariupol, at Novolipetsk, at Cherepovets, at Novotroitsk and in other towns. An example of the magnitude of the expansion is indicated by the Magnitogorsk Iron and Steel Works, where the current program will result in an output of 9,300,000 tons a year of rolled metal by 1965. In the central area of the country, the plant which will have the greatest development is the Novolipetsk Iron and Steel Works where the plant will have an output capacity equal to the present Magnitogorsk Iron and Steel Works, and will emphasize electrical sheet, pipe and plate products.

About 85 per cent of Russian steel output comes from open hearths, 6 per cent from converters, and 9 per cent from electric furnaces. The share of converter steel will be increased by the current expansion program. Converters up to 235 net ton capacity are planned.

The government of Morocco is planning a new steel plant at Ras Kebdang on the Mediterranean coast. Initial production is projected for 1962 with an annual rate of 165,000 tons of rolled products.

There are reports that the South African Iron and Steel Industrial Corp. (Iscor) at Pretoria have a new expansion plan which includes a new mill, probably in Natal. This should raise ingot production to about 4,400,000 net tons a year by 1970, compared with the existing 2,000,000 net tons.

Engineering reports have been made on the possibility of building two steel plants in Pakistan. One would be a 250,000-ton plant at Karachi. The other would be a 100,000-ton plant at Chittagong.

India is a country in which present capacity lags far behind demand, so far that unavailability of steel is holding back the industrial development of the nation. Nevertheless, even here, the feeling of the government planning council is "Right policy for India is to seek not only steel self-sufficiency, but also development as a steel exporting country." The present target in India is now a capacity of 6,600,000 net tons in 1961. This will go up to 11,200,000 tons by 1966. This breaks down into the following plant capacities: 2,750,000 tons at Bhilai; 1,800,000 tons at Durgapur; 2,000,000 tons at Rourkela; 1,100,000 tons at Bokaro, a new plant; 2,200,000 tons at Tata; 1,100,000 tons at Burnpur; 100,000 tons at Mysore; plus 200,000 tons miscellaneous, or a total of 11,250,000 net tons.

The Durgapur plant is scheduled for completion by July, 1961. Two blast furnaces are already operating.

The third stage of the Durgapur plant, with target of April 30, 1961, will see the completion of the third coke oven battery, the third blast furnace, the remaining four of the seven open hearth furnaces, a 24-in. medium section mill and a continuous merchant mill. The final stage will complete the open hearth shop, a foundry and a wheel and axle plant.

At Rourkela, three 45-ton oxygen converters, four 90-net ton open hearth furnaces and two of the three blast furnaces were in operation by the spring of 1960. The steel plant will have an annual capacity of 1,100,000 net tons. India is reported to be basing plans for future steelmaking capacity on additional converters.

Rourkela also has put into operation a wide strip mill consisting of two 4-high roughing stands (one of which is reversible), and six 4-high finishing stands. This mill will roll strip $\frac{1}{16}$ to $\frac{3}{8}$ in. finished gage in a maximum width of 62 in. The rolled strip leaves the last stand at 2400 fpm.

Tata Iron and Steel Co., Ltd., put into operation a continuous light section mill at Jamshedpur. This mill consists of a six-stand roughing train with four horizontal stands and an edger, a finishing train with two horizontal and two vertical stands, and a single strand rack type cooling bed with handling facilities. The mill will be able to produce rounds, squares, flats, angles, tees and channels from 3 x 3, 4 x 4, and 4 x 5 in. billets.

Studies are under way for the construction of a new steel plant in the Philippines, designed to produce about

250,000 net tons of finished steel products. The plant will be built at Iligan on the Philippine Island of Mindanao.

One of the largest steel plant construction and modernization programs—and perhaps the boldest for the size of the country—is underway in Japan. Involved are new integrated plants, modern automatic rolling mills, and the use of the latest operating techniques. Japan will end with a modern, low cost steel industry with which American steelmakers must reckon in the future. The location of many of the plants on tidewater will be an advantage in Japan's drive for markets. Much of the new equipment in Japan is coming from the United States.

Steel production in Japan was estimated at 24,300,000 net tons in 1960. Pig iron production for 1960 totaled some 13,000,000 net tons. Estimates for future steel production are going up. In 1959 it was estimated that steel production by 1970 would be some 42,000,000 net tons whereas estimates made in 1960 increased this to 53,000,000 tons. This would meet some 49,000,000 tons of domestic demand and 4,000,000 tons of export.

Raw materials are a problem but in March, 1960, Japan signed an agreement on the development of Bailadila iron ore mine in India.

They estimate also that the production ratio of open hearth steel compared with converter steel will change from the present 4 to 1 ratio to a new ratio of 2 to 3. In order to produce the amount needed for this program (37,000,000 net tons) it will be necessary to construct 30 more 2200-ton per day blast furnaces and to import 54,000,000 tons of ore and 27,000,000 tons of coal. A total of $8,300,000,000 will be needed to finance the construction of new steel plants and modernization of others.

Open hearth capacity is to be 15,500,000 net tons, converter capacity is to be 13,200,000 tons, and electric furnace capacity is to be 6,600,000 tons in 1965. This will give a total of steel capacity of 35,300,000 net tons in 1965.

In 1961, construction is scheduled to start on nine blast furnaces; in 1962 one furnace is scheduled and in 1963, five more are due to be started.

Japan has an extensive program for building continuous galvanizing capacity. Eleven companies have lines scheduled for completion between 1961 and 1968. The program is as follows:

Company	*Location*	*Annual capacity, tons*
Yawata Iron & Steel Co.	Tobata	72,000
Fuji Iron & Steel Co.	Muroran	72,000
Nippon Kokan	Mizue	96,000
Kawasaki Steel Corp.	Chiba	10,000
Sumitomo Metals Industry		
Daido Steel Sheet		72,000
Tokai Iron & Steel Co.		72,000
Nisshin Steel Works	Osaka	
Osaka Shipbuilding Co.		60,000
Nakayama Kogyo	Tsurumi	72,000
Yodogawa Steel Works	Kure	72,000

Nippon Kokan Kabushiki Kaisha (Japan Steel & Tube Corp.), the third largest producer in Japan, is building a new flat rolled products plant (Mizue Works) adjacent to their Kawasaki Works which will have an eventual capacity in 1965 of 1,500,000 net ingot tons. The first stage includes a slabbing mill, continuous hot strip mill and a reversing cold mill. An oxygen converter, with an annual capacity of 770,000 tons, was completed in March, 1960. The hot strip mill has a roll length of 67 in. and an annual capacity of 1,300,000 net tons. Additional work on the program consists of two 1650-ton blast furnaces, coke ovens, sintering lines, an additional 66-ton oxygen converter, expansion of hot rolling facilities, a new tandem mill, a new tinning line, and a silicon plate mill. Completion is scheduled for 1965.

In addition to the Mizue Works, Nippon Kokan's long term program includes another complete steel plant, to be built in the period 1965 to 1970, on a new site, with an annual capacity of 2,200,000 net tons. This steel plant will be built with three 2200-ton per day blast furnaces, three 110-ton oxygen converters, and two 330-ton open hearth furnaces. There will also be blooming, plate, large structural hot rolling mills, galvanizing and tinning lines.

The Kawasaki Works of Nippon Kokan put their No. 5 blast furnace in operation in May. Future construction at the Kawasaki Works includes installation of a blooming mill, remodeling the No. 5 pipe mill, increasing medium diameter seamless tube mill and additional construction of buttweld tube mills. Plant will have capacity in future of 1,300,000 net tons.

At the Tsurumi Works of Nippon Kokan there will be remodeling of the No. 2 blast furnace, increasing capacity of open hearth to target of 900,000 tons, and increasing capacity of plate mill, and large diameter buttweld mill.

Yawata Iron & Steel Co., Japan's largest producer, completed work on a modernization program at Tobata Works. This included one 1650-ton blast furnace and a 66-ton converter which started operation in November, 1960.

Yawata announced its third modernization program in late 1959. This covers the period 1960 to 1965, at the end of which annual iron capacity will be increased to 6,500,000 net tons compared with 3,200,000 net tons at the end of 1959. Ingot steel capacity will be 7,600,000 net tons compared with 4,670,000 tons in 1959. The program cost is estimated at $4,400,000,000.

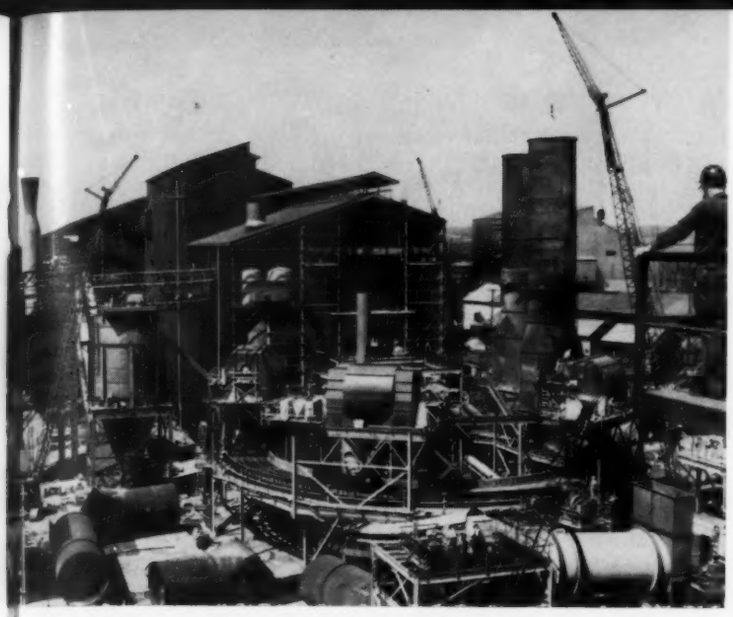
New coke ovens and a sintering plant, will be built by Yawata at the Tobata Works, as well as a 2200 ton per day blast furnace, two 110-ton oxygen converters, a tandem cold strip mill, an electrolytic tinning line and a continuous galvanizing line.

At Yawata's Hikari Works, a 44-ton electric arc furnace will be completed in 1963.

At the Sakai Works of Yawata Iron & Steel Co., a new integrated mill in Osaka, there will be two 2000-ton blast furnaces, a sintering plant, three 90-ton converters, a blooming mill, large section mill, hot strip mill, cold strip mill, etc.

At Yawata's Yawata Works, a new 3000-ton per day sintering plant is being built. Extensive modernization of other facilities are also programmed.

Work was started during the year on the new plant of the Tokai Iron & Steel Co. which may become one of the largest integrated steel plants in Japan. By 1975



The sinter line at the Aliquippa Works of Jones & Laughlin was completed this year. Plant has a strand 13 ft-2 in. wide and will produce 6500 tons of sinter a day.

the company plans to build five 2200-ton, high top pressure blast furnaces with an annual capacity of 5,000,000 net tons. In addition the plant will have three 100-ton converters, bar and section mills, and cold rolling mills.

The Fuji Iron and Steel Co. started a new large blooming and slabbing mill at the Hirohata Works in June. The mill has an annual capacity of 2,650,000 net tons. Rolls are 90 in. long. The mill has a card system automatic control.

Fuji Iron and Steel also completed a 1650-ton blast furnace in October at the Hirohata Works. A new blooming mill at Muroran Works went into operation early in the year.

The Osaka Steel Co., will complete a new wire rod mill at its Nishijima Works in September, 1961. The new mill will be capable of turning out wire rod from 0.20 to 0.63 in. with a monthly output of 27,000 tons in coils weighing 660 lb. The company started a 330-ton blast furnace in April, believed the smallest unit in Japan. The burden for this furnace will be a low quality indigenous ore.

The Kawasaki Steel Corp., started their No. 3 blast furnace with a daily capacity of 1650 net tons at the Chiba Works.

The Kobe Steel Works, Ltd., ordered a $10,000,000 continuous merchant bar mill with a production capacity of 25,000 tons per month. It will roll round and square bars, angles, channels and other steel products.

Early in 1960, Sumitomo Metal Industries started up a new blooming mill, rated at 1,300,000 tons per year, at their Wakayama Works. The mill uses two stands in tandem. It can handle ingots weighing up to 25 tons.

An extensive industrialization and steelmaking program is underway on the mainland of China. The Reds claim that steel production in 1959 exceeded 13,000,000 tons, well below the 18,000,000-ton original target. Some people, however, estimate that the actual output was closer to 7,500,000 tons.

At the Anshan plant in Manchuria, the tenth and largest blast furnace, which is about 45,000 cu ft in volume, with a daily capacity of 2750 net tons of pig iron, recently went into production. Also, three open hearth furnaces with a reported capacity of 550 to 660 tons of steel per heat have gone into operation.

In the Wuhan steel center in Central China, there are two large blast furnaces in operation (about 40,000 cu ft), and three 550-ton open hearth furnaces with eight more open hearths planned. Two other blast furnaces are also to be built.

Experimental work is underway in blast furnaces on using a local fluorine-bearing iron ore.

The third large steelmaking center in China is to be the Pao-t'ou in Inner Mongolia. Its first blast furnace, a 2750-net-ton per day unit, was started recently.

In Korea the Daihan Heavy Industry Corp. started a 27-in., 3-high blooming mill and a 3-stand, 3-high medium section mill at their new plant near Inchon. The mill will eventually produce 110,000 net tons of steel a year.

RAW MATERIALS

In general, raw materials presented no problems in 1960. The development of various sources in the past few years seems sufficient for capacity operations of the steel industry, and is more than adequate for the going rate.

Iron ore—Ore developments underway have been of two types, one aimed at high grade ores, the other aimed at development of areas which have ores lending themselves to relatively easy beneficiation. Much work is also being done on building facilities to upgrade, agglomerate and pelletize ores.

By the end of November, 1960, some 110,096,758 gross tons of ore had been received at steel industry's plants. These same plants had consumed by that time a total of 96,369,220 tons during the year and had an inventory on hand of 70,361,708 tons. The United States imported 22,618,533 tons of foreign ores up to December 1, plus 10,763,201 gross tons from Canada. Of the ore produced in the United States, some 62,681,301 gross tons came from the Lake Superior region, and 14,033,-723 tons from other areas. Of the Canadian ore, 3,318,-158 tons were Lake Superior region ores.

The total amount of ore shipped down the Lakes in the year 1960 totaled about 69,631,789 gross tons. This was lower than expected since the season started with a rush, but the total is still the best year since 1957.

Of the ore shipped, a higher portion was beneficiated ores. It is estimated that shipment of iron ore pellets from the United States plants in 1960 would total 11,500,000 gross tons, with about 500,000 tons additional being made in the Canadian plants to give an over-all total of over 12,000,000 gross tons.

Pellet-making capacity in the United States is estimated at about 14,000,000 gross tons at the end of the year. This is expected to more than double in the next four years.

Reserve Mining Co. started construction work to expand their taconite processing facilities by about 50 per cent at an estimated cost of about $120,000,000. The major object is to increase pellet producing capacity to over 9,000,000 gross tons from the present capacity of about 5,500,000 tons. Completion of expansion is scheduled for the middle of 1963.

The International Nickel Co. of Canada, Ltd., is going ahead with expansion of its iron ore recovery

plant at Copper Cliff, Ont., which will triple its capacity. Expanded plant will be in full operation by 1963. The plant will treat some 1,100,000 gross tons of nickel iron ore and the iron ore recovery plant will produce pellets with 68 per cent iron. A capacity of 800,000 gross tons of these pellets is scheduled.

As to domestic ores, the experts predict that the increased production of high grade agglomerates from taconites and jaspers will in part supplant the standard grade ores from the Lake Superior district. Estimates are that taconite capacity will increase from 20,000,000 tons in 1960 to 50,000,000 in 1980, and the standard grades will decrease from 64,000,000 to 30,000,000 tons over the same period. It is assumed also that standard grade ores will, for the most part, be premium products which have been ungraded by beneficiation to meet the demand for high quality furnace feed.

The Humboldt Mining Co. plant, near Ishpeming, Mich., put into operation a grate-kiln system for agglomerating and pelletizing iron ore concentrate from low grade, jasper rock. The two new lines at this plant, rated at 1000 tons per day each, provide an annual pelletizing capacity of 650,000 tons. There are expectations that this plant will be enlarged to an eventual goal of 6,000,000 to 7,000,000 tons of pellets by 1970.

Similar equipment has been ordered by the Marquette Iron Mining Co.'s Republic, Mich., mine.

It is understood that an adaption of the grate-kiln system may be used for iron ore reduction. Experiments have been done in a laboratory reduction kiln that also serves as a gas cracker or reformer. Unused reducing gas and unreacted fuel are burned to provide the reaction heat. The raw material consists of concentrated magnetite pellets containing about ten per cent more carbon than theoretical reduction requirements. The iron pellets produced have been found suitable as a feed for hot blast cupola and electric arc furnaces. Batch experiments have produced pellets that were 91 per cent reduced.

Jones & Laughlin Steel Corp. started a new ore mine called the Lind-Greenway at the extreme west end of the Mesabi Range during the summer. This unit is expected to produce about 700,000 gross tons of high grade ore a year.

The Caland Ore Co. Ltd., a subsidiary of Inland Steel Co., dedicated its mining operation near Atikokan, Ontario. The capacity of this plant will be 3,000,000 tons a year by 1969. Investment involved at that time will be about $66,000,000. This ore company was formed to develop an ore body beneath the waters of an eastern arm of Steep Rock Lake. Present mining is by the open pit method; underground development is under way and should start in 1963. The company expected to ship 750,000 tons of ore in 1960.

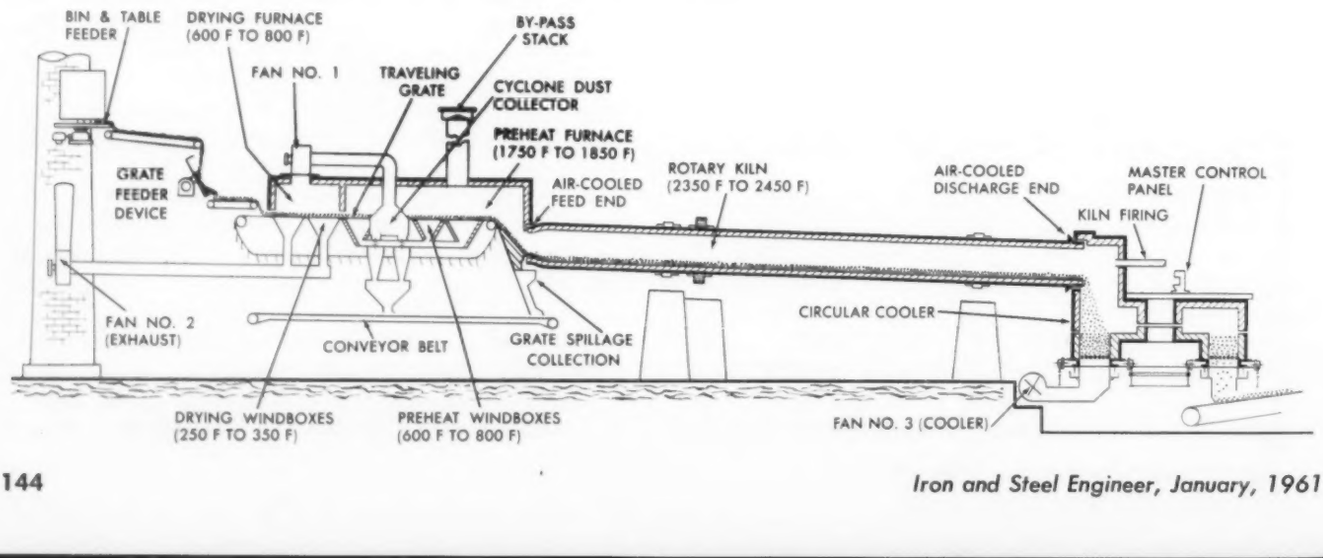
The M. A. Hanna Co. will build a pilot beneficiating plant costing about $2,000,000 near Cooley, Minn., with a capacity of about ten tons of iron ore per hr. The Oliver Iron Mining Div. of the United States Steel Corp. is to build a similar facility with a capacity of five tons per hr at Coleraine, Minn. These two units will be built to test the processing of semi-taconite, a low grade ore. This is a form of iron ore that now has no commercial use, is much softer than regular taconite and easier to mine and crush. It is nonmagnetic and cannot be concentrated by the same processes used for magnetic taconite. Both of the pilot facilities will experiment with a roasting process to change the ore chemically into the magnetic form.

Columbia-Geneva Steel Div. of the United States Steel Corp. started development of an ore body in Fremont County, Wyoming, which will be called the Atlantic City project. By late 1962, ore mining, concentrating and pelletizing operation will be underway and the company will supply pelletized iron ore to the Geneva works. Conventional open pit methods will be used to mine the ore which contains about 30 per cent iron. The ore will be magnetically concentrated to more than 60 per cent iron.

In September, Roger Blough reported that the United States Steel Corp.'s new iron ore project in northeastern Quebec, being developed by the Quebec Cartier Mining Corp., will start shipping high grade iron ore concentrate by mid-1961. This project, costing more than $200,000,000, will have a capacity of about 8,000,000 tons of ore concentrate annually.

In addition to the Quebec Cartier development, a second project of about the same size is being carried out by the Iron Ore Co. of Canada, the largest iron ore producer in Canada, in the Carol-Wabush Lakes area of Labrador. In 1959 it shipped 12,600,000 tons of direct shipping ore from the Schefferville operation. The new project will add capacity for 7,000,000 tons of iron ore

Several ore preparation developments are using the grate-kiln process.



concentrate annually, with initial production planned for 1962. Estimated cost is more than $250,000,000.

Another project is being carried out by the Wabush Iron Ore Co. A pilot plant is now near completion. The operating plant will probably run from 4,000,000 to 5,000,000 tons of concentrated ore per year, with initial production set tentatively for 1964.

A proposal on which details are not known is sponsored by the Ungava Iron Ores Co., which is controlled by American and German steel companies. They plan to erect a plant which will produce 65 per cent iron pellets, and have under consideration, the construction of a transit harbor in Greenland.

Can-Fer-Mines Ltd., announced that recent exploration and tests indicate that they have located an ore body with 130,000,000 tons of magnetic iron ore which can be concentrated. This body is located on the Canadian National Railway, less than 200 miles from the Lake Superior ore docks. It is reported that they were aiming at an output of 2,000,000 tons of pellets per season from a plant estimated to cost about $30,000,000 with ore scheduled to begin moving to the market by the 1962 season.

The M. A. Hanna Co. have plans for a $40,000,000 project in Brazil, where there is a 300,000,000-ton deposit of hematite assaying about 64 per cent iron. Most of this lies on or close to the surface. The properties are not too far away from the Vale do Rio Doce mine, which is operated by the Brazilian government.

Coal—The heavy emphasis on agglomerating ores and on sintering has cut markedly into the reserve stock piles of coke breeze and increased the comparative price and value. As a result, it appears that there may be a market in the future for anthracite fines for sintering and pelletizing iron ores.

A large coal mine, which went into operation in June, is operated by Old Ben Coal Corp. The mine taps a reserve of about 100,000,000 tons of low sulphur coking coal near Benton, Ill. The coal is located about 670 ft below ground level. Production by 1962 should be 3,000,000 tons per year.

Nickel—In the United States, nickel consumption in 1960 was about 215,000,000 lb compared with 228,000,000 lb in 1959. In the free world, nickel consumption set a new high of over 500,000,000 lb. Magnesium consumption was set at 51,000 tons, the same as 1959.

One source of nickel ore was lost to the United States when Fidel Castro seized the Moa Bay Mining Co.'s facilities in Cuba. This plant was capable of producing raw materials for 50,000,000 lb of nickel a year which would have been refined in Louisiana.

Aluminum—There is a great deal of optimism in the aluminum industry and estimates are that free world consumption of primary aluminum will more than double by 1970. For 1960 world consumption was estimated at some 4,659,000 tons, of which 2,210,000 tons were consumed in North America.

Total 1960 industry shipments of primary aluminum were about 4,100,000,000 lb. This figure includes both domestic and import figures.

Aluminium Ltd., in Canada, announced that it had a process for making aluminum by direct reduction of bauxite into aluminum. The company is to build a pilot plant of 6000 to 8000 tons capacity to test the process. The present process is a 2-step process which first converts bauxite ore to aluminum powder and then changes it to aluminum pig. A large French producer is also reported to be working on a 3000 to 5000-ton pilot plant for direct reduction. The advantages of such a process would be cheap initial investment and lower operating costs.

The blast furnace shell and superstructure for Granite City Steel's new furnaces were built some 87½ ft from their final location.

Alcoa announced it will spend $18,000,000 to expand and modernize its two major sheet mills at Davenport, Iowa, and Alcoa, Tenn., to meet a sharp rise in demand for aluminum sheet products. Included for Davenport is a tandem, 4-high cold rolling mill, and at Alcoa, Tenn., additional equipment will be installed to support a new 4-high, 4-stand rolling mill, on which trial runs are now underway.

Alcoa put into operation a new potline at Warrick, Ind., in 1960. This is the first phase of an $80,000,000 smelter job which will have an eventual annual capacity of 175,000 tons. The first potline is rated at 35,000 tons. The schedule of the remaining four depends on future market conditions.

Kaiser Aluminum & Chemical Corp., announced a $4,100,000 expansion program in December. Under this program an aluminum fluoride plant will be built at Gramercy, La. At Chalmette, La., there will be a major expansion of facilities to produce extrusion billets. This program will increase capacity for forming high quality billets about 50 per cent. New equipment to be installed will be able to form billets ranging from 3½ to 12-in. in diameter in lengths up to 220 in.

The Kaiser Aluminum & Chemical Corp. and Consolidated Zinc Corp. Ltd., announced late in the year that they plan to start a new aluminum industry in Australia and New Zealand. This includes development of bauxite mining reserves and hydroelectric power as

well as the largest integrated aluminum facilities in the southern hemisphere. Included is a 360,000-gross ton alumina refinery at Weipa in northern Australia, expansion of aluminum reduction works in Tasmania, and construction of a new aluminum reduction plant at Bluff, New Zealand. This latter plant will have a capacity of 120,000 gross tons of primary aluminum annually. Completion is tentatively scheduled for the middle of 1966.

The Harvey Aluminum Inc., Torrance, Calif., announced that it is expanding its aluminum reduction capacity by 25 per cent.

BLAST FURNACES AND COKE PLANTS

The better preparation of raw materials by sintering, pelletizing and briquetting has been showing up in blast furnace operation. In the last few years production of the best blast furnaces have run about 2000 tons a day. Reports in 1960 from Armco Steel indicate that they have been averaging up to 2700 tons per day from a blast furnace with a 70 per cent charge of ore pellets. Some experts predict that ultimately it will be possible to get 28-ft furnaces producing up to 3000 tons per day. Coke rates could also go down under 1000 lb.

New blast furnaces which are being planned call for two tapping holes which will probably be needed when projected production is attained.

The principal methods being used to improve blast furnace practice include beneficiation of raw materials, the use of self-fluxing sinter, higher top pressures, higher blast temperatures and additions of moisture, oxygen, fuel oil, coke oven gas and natural gas to the blast.

The development of pelletizing is following the same pattern as sintering. Machines are presently available which produce between 2500 and 3200 tons of pellets per day, but designs for machines capable of producing 5000 tons per day are being considered. The auxiliary equipment presents some problems. Balling equipment is very vital to the pelletizing process. In most if not all of the large commercial pelletizing plants, bentonite is being added to make a ball which is capable of being handled, dried and heated with a minimum amount of breakage.

The new sinter plant at Inland Steel Co.'s Indiana Harbor Works has a daily production of 4000 tons. The operation of this plant is controlled from one instrument station, and all material flow and machine speeds are regulated from the main control desk. This plant has a circular cooler with a main working diameter of 80 ft which reduces sinter temperature to 250 F.

At Jones & Laughlin's Aliquippa Works, the new 13 ft-2 in. wide line started operation at the end of the year. This line is designed for 6500 net tons of self-fluxing sinter a day.

Construction is underway at Interlake Iron Corp.'s Chicago plant on a new sinter plant which will have a capacity of 3360 net tons of sinter a day. This unit will be equipped with a straight-line induced draft cooler. This is a single strand sinter machine, 8¼ ft wide and 151 ft from center-to-center of sprockets. The cooler will be 224 ft long and will lower the temperature of the sinter from 1450 to about 235 F.

The Youngstown Sheet and Tube Co. recently installed an x-ray device on their new sinter line which analyzes the content of five elements in the sinter. The device makes it possible to automatically proportion the product on the basis of the weight of the elements in the ore and adding those which are necessary to the sintering process.

Reports from England indicate that an investigation there shows the use of air preheated to about 550 F during the first third of sintering of an ore mix reduces coke requirements from 6 to 5.1 per cent, or a saving of 15 per cent, and the overall thermal requirements by nine per cent. The optimum rate of heat input and percentage of excess air during ignition remain about the same as in normal sintering, but to avoid surface slagging, a reduction in total heat input during ignition of approximately 25 per cent is required.

United States Steel Corp. announced that it plans to build a 28-ft hearth blast furnace at the Duquesne works. This unit is to be designed to permit research studies on the effects of top pressures up to 30 psi, hot blast temperatures in the range of 2000 F and controlled sizing of burden. It will have automatic probing of the stock column and very advanced instrumentation. The furnace is scheduled to be completed in two years and should produce some 850,000 tons of iron annually. Serving the furnace will be three hot blast stoves, a modern turboblower and other equipment.

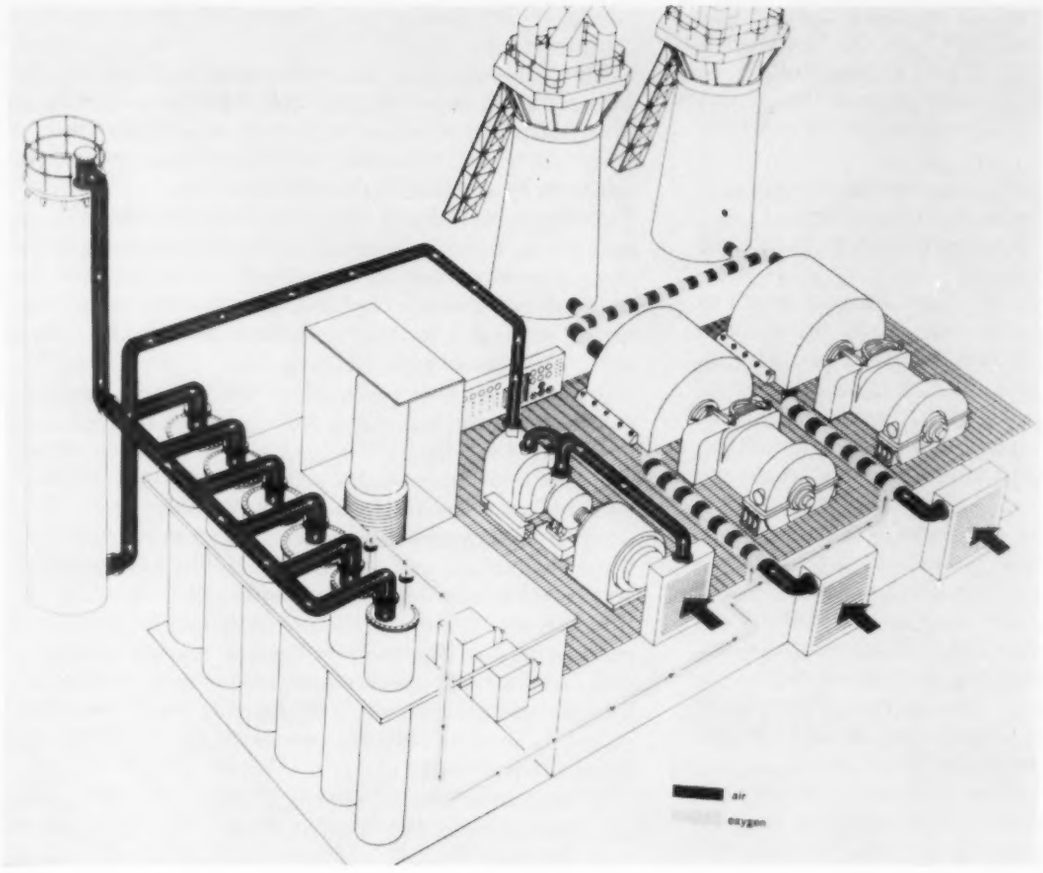
United States Steel Corp. also let contracts for the construction of a small experimental blast furnace which is being installed at the Universal Atlas Cement Div. plant at Universal, Pa. This unit incorporates many features to permit research on the various phases of blast furnace operation. It is designed to operate at much higher pressures than the conventional blast furnaces, with larger volume of blast air. Some of the research tools for this unit are automatic probes to record gas composition and temperatures, an infrared analyzer for continuous analysis of top gas, and fully automatic equipment for sizing, weighing and charging new materials. The hearth diameter will be four ft, working height from tuyeres to stockline will be 19 ft-6 in., and the unit will be designed to operate at a maximum top pressure of 50 psi. Stoves will be designed to heat air to 2500 F.

The Colorado Fuel and Iron Corp. had underway a complete rebuilding job of their "A" blast furnace. Hearth diameter is being enlarged from 20 ft-9 in. to 22 ft-9 in. The unit is expected to produce 800 tons per day compared with 650 tons prior to the rebuild. Carbon will be used in the bosh. The furnace is also being converted from 12 to 16-tuyeres.

Granite City Steel Co. is also reconstructing a blast furnace. It will be able to produce about 1800 tons of pig iron a day, about double that of the unit which is being replaced. This will bring total annual pig iron capacity in Granite City to 1,134,000 tons a day. The new furnace was built off the site and then moved into position to reduce downtime.

Granite City also ordered a new battery of 61 by-product coke ovens which will go into operation late in 1961.

A great deal of work has been done with electronic computers to simulate the operation of the actual blast furnace. These studies have pointed out a number of possibilities for increasing productive capacity at low



Tying the oxygen plant in with blast furnace blower setup can result in operating economies.

cost. A comparison of the computer predictions with results measured in furnaces where this has been possible has shown the method to be quite reliable.

An instrument is available which can simultaneously determine and record percentages of hydrogen, carbon monoxide and carbon dioxide in the top gases of a blast furnace. A high velocity sampling system continuously pumps a flow of sample gas, cleaning it and delivering it under increased pressure to the analyzing cells. Two measurements of gas measurement are used: thermal conductivity and infrared absorption. The measuring cells have no moving parts and require no replacement of chemicals or other sensitizing elements. All gas percentages are simultaneously displayed on the same chart.

The system for injection of gas into the blast furnace at The Colorado Fuel and Iron Corp.'s Pueblo plant, in operation on one unit for over two years, is now being installed on all four furnaces there. The use of up to five per cent natural gas has improved operating characteristics. Future improvements in stove heating capacity and oxygen enrichment of the blast are expected to extend the range of gas usage. CF&I has also developed techniques for injection of other fuels into the hot blast but these are still basically in an experimental stage. A short trial run has been made with oxygen enrichment and extensive experiments will be made when the new oxygen plant is completed early in 1961.

Summarizing, the injection of natural gas into the hot blast at rates as high as five per cent of the wind volume has resulted in a coke saving on the order of 75 lb per net ton of hot metal for each 1000 cu ft of gas used. The coke savings and production rate depend on the amount of blast temperature increase; 70 to 80 F temperature increase for each per cent natural gas gives good results. For example if five per cent natural gas is used, the blast temperature should go up about 370 F.

CF&I is also experimenting with fuel oil injection with natural gas. This acts as a temperature stabilizer and seems to offer better control of heat. It also helps produce pig iron of a more consistent quality.

The fuel oil is atomized into the natural gas stream and the mix is fed into the hot blast as it passes to the tuyere. The oil supplements the natural gas which can be added only in limited amount.

With fuel injection, coke rates as low as 1140 lb per ton have been achieved.

Lone Star Steel Corp. also reports good results from use of natural gas in blast furnace operation. They started by adding one per cent to the furnace and this has now been increased to four per cent in some cases, with a coke reduction of ten per cent.

Both coke oven and natural gas are being used at the Neville Island plant of Pittsburgh Coke & Chemical Co., the use resulting in smooth furnace operation at the highest temperatures the stoves can provide. Initially, coke oven gas was used because it was available as a by-product from the company's coke ovens, and because it contains a high percentage of hydrogen for reducing. The company would have continued to use the gas but the supply ran short and natural gas was piped in to keep the stack on the new practice.

The gas flow is fed through a 6-in. pipe which encircles the furnace above the bustle pipe. Twelve downlegs from this pipe carry gas into the blow pipes. The typical lance is set back about four in. from the tuyere nose.

Other companies reported to be using natural gas or coke oven gas are Armco Steel Corp., McLouth Steel Corp., United States Steel Corp. and Kaiser Steel Corp. Most of the applications have been on an experimental basis but extensive production trials are to be expected in the near future.

Companies which have been using fuel oil experimentally, in addition to The Colorado Fuel and Iron Corp., are United States Steel, Dominion Steel & Coal, and Dominion Foundries & Steel.

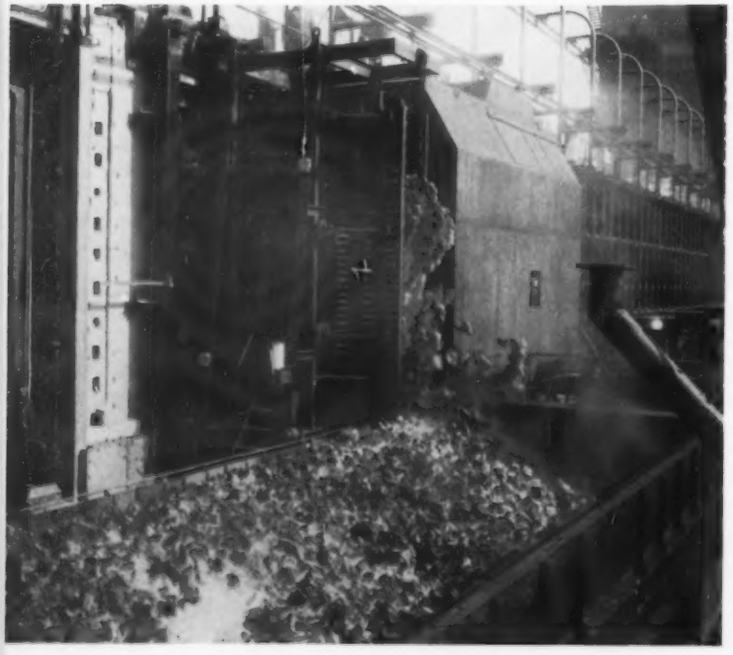
Some major advances in the blast furnace area are reported from Russian plants. One of the largest furnaces will have a volume of 95,000 cu ft. The blast furnace profile is being changed by a relative decrease of height, relative narrowing of the furnace gorge and broadening of the hearth. Thus, the shaft angle of the furnace has been decreased, and the belly angle increased.

At the Cherepovets Iron and Steel Works blast furnace plant, the raw material is fed into the blast furnace hoppers by conveyors. This plant operates on 100 per cent fluxed sinter produced from an ore concentrate of constant quality and delivered always from the same ore deposit. Secondary screening is done on vibrating screens. Sinter is air-cooled in pan coolers. These blast furnaces operate on a top gas pressure of 22 to 27 psi with a hot blast temperature of 1900 F.

The Russians report that some 70 blast furnaces were operating on high top pressure the beginning of 1959 and these furnaces produced 82 per cent of the total pig iron. On most furnaces the top pressures run to 12 psi, but some use up to 15 and even 22 psi; one furnace operates steadily at 27 psi. They report that pressure of 10 psi raises blast furnace efficiency by five to eight per cent, reduces coke consumption by 1.5 per cent, and decreases dust by 32 to 50 per cent.

The Russians use humidity control on most of their furnace operation. However, in some cases blast humidity is lowered; while temperature is raised to a maximum.

A 59-oven battery was one unit which went into operation at the Pittsburgh Works of Jones & Laughlin. Two other batteries are under construction at the Pittsburgh Works.



The Russian coke rate continues to drop. At the Magnitogorsk combine, coke consumption was reduced from 1254 lb per net ton in 1959 to 1236 in 1960. A lower rate was achieved at Cherepovets, where the coke rate is now 1198 lb per net ton of iron.

At Petrovskii Works, the use of natural gas in smelting iron along with an increase in blast temperature, increased productivity by three to five per cent and the coke rate was reduced by 12 to 15 per cent. Reductions in the same general range were accomplished at three other blast furnace installations.

Stanton Ironworks Co. Ltd., Nottingham, England, reports that the air-cooled carbon hearths which they have had in service have helped solve the hearth erosion problem and reduced the penetration of the firebrick pad and the furnace foundation by molten iron. Two completely different designs were used. In relining their furnaces, carbon was placed on a cooled bottom plate. No firebrick was used under the carbon, as it was felt that this would reduce the benefit gained from the high conductivity of the carbon. On one furnace a parallel grid system was used consisting of mild steel joists 6 x 5 in. laid parallel below the hearth. Ducts were completed by welding plates across the joists. Two 4400-cfm fans were provided.

In this arrangement alternate ducts were connected together and the exit flues provided with dampers so that the flow through any section could be controlled. Hearth walls were constructed of standard carbon brick and a pad of interlocking corrugated blocks, 12 x 12 x 20 in. This furnace has been in operation since August, 1958. From temperature readings on the hearth, it is believed that only slight errosion has occurred. All indications are that the carbon is practically intact.

Since measured temperatures in the previous furnace necessitated modifications in the air distribution to keep the temperature at the center down, it was decided when relining the second furnace to have the maximum cooling at the center of the hearth. In this design, the cold air is taken direct to the center of the hearth and comes out a series of radial ducts, thus giving maximum cooling at the point it is most needed.

Improvement in furnace refractory maintenance are due to newly developed castables, gun clays and installation techniques. These can help producers get more tonnage out of the good brickwork still in the furnace. A complete monolithic gunning maintenance installation can be done in ten days or less, compared with 40 to 60 days for complete brick lining on a blast furnace.

In the past few years several attempts have been made to incorporate nuclear or radioisotopes in the lining of blast furnaces to be used as a check on lining wear. At The Colorado Fuel and Iron Corp., it became necessary to patch the furnace after the last strike. The repairs were made with castable refractories. To determine the life of the patch, radioactive material was buried in the castables at six locations and have since been checked at frequent intervals with a geiger counter to see if the castable is still in place in each location. The radioisotope chosen was cobalt 60 sealed in stainless steel needles.

An interesting kink in blast furnace overhauling is

used at a number of plants. Folding swinging scaffolds have speeded up relining jobs. The scaffolds usually consist of hinged steel platforms with extendable arms which can be adjusted to conform with the stack diameter. The platform can be used for lining removal and inspection.

A new concept in oxygen facilities for steel mills, shown at the 1960 Iron and Steel Exposition, makes full use of blast furnace gas and standby or excess turboblower capacity in conjunction with a tonnage oxygen plant. Blast furnace gas is used to generate steam which in turn drives the turboblower. The excess of spare turboblower capacity minimizes the compressor requirement for oxygen production. In this design, the oxygen unit is placed immediately adjacent to the turboblowers.

The following arrangements are typical examples:

1. Excess blast furnace air, say 15,000 cfm is used with a booster compressor to produce 150 tons per day of 99.5 per cent purity oxygen.

2. A spare blast furnace blower is used to produce 600 tons per day of 60 to 70 per cent purity oxygen.

3. A spare blast furnace blower is used in combination with other compressors to produce 600 tons per day of 99.5 per cent purity and 700 tons per day of low purity in three oxygen units.

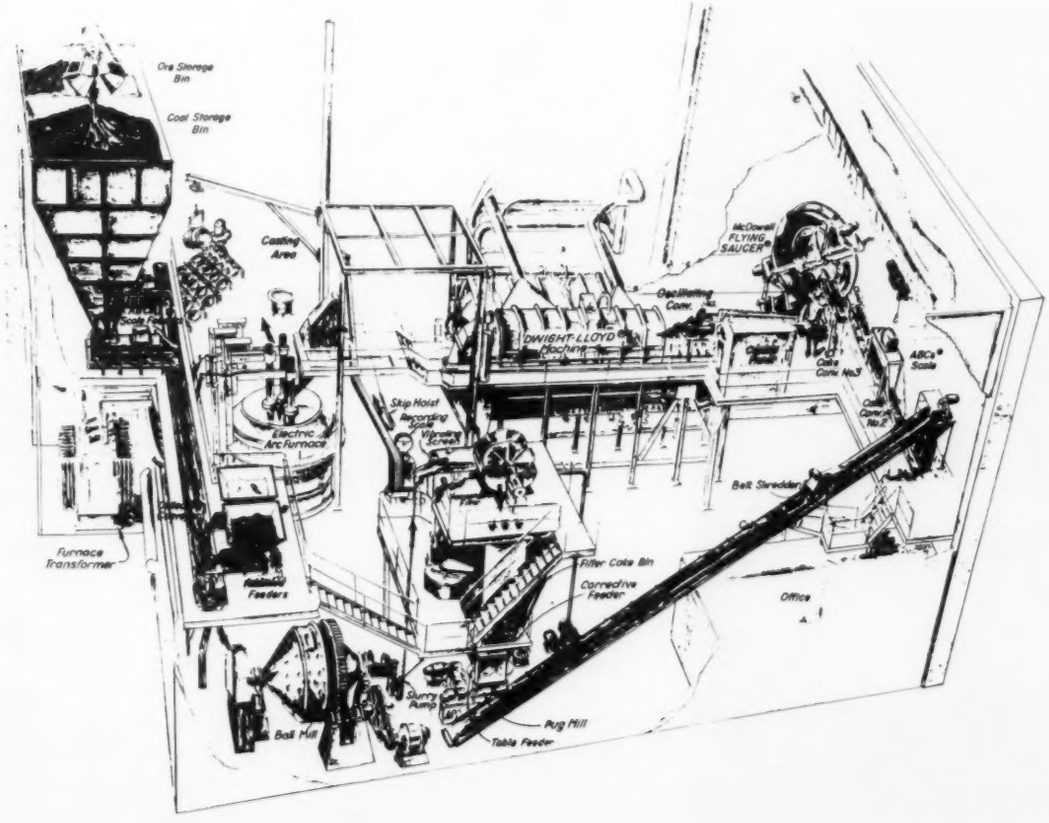
United States Steel Corp. reported that their pilot work on the Nu-iron process shows it to be technically feasible. This is a two-stage iron ore fluidized bed reduction process using hydrogen. A 2000-ton per day commercial unit had been designed but economic reasons have delayed construction. An evaluation of the process with present conditions shows that it is not competitive with the blast furnace process as a source of iron for producing steel ingots, except where coke and coal are not available and where natural gas is very cheap.

It was reported in September that a company called the New Mylamaque Explorations, Ltd., signed a contract for the construction of a smelting plant near Kingston, Ontario, for the production of 150,000 tons annually of iron by the Strategic-Udy direct reduction process. The estimated cost is $14,000,000. Construction is scheduled to begin early in 1961.

The second H-Iron plant in this country was completed recently for Bethlehem Steel Co. at its Los Angeles plant. Rated at 110 tons per day, the plant is producing iron in sufficient quantities for extensive trials in electric furnaces.

A paper on the Dwight-Lloyd-McWane direct reduction process, given at an AISE meeting this year, reports that production costs in a plant in the Lake Erie area would be about equivalent to that in a new 3000-ton blast furnace plant. However, it is estimated that the blast furnace capital cost would run around $90 per annual ton; the investment per annual ton by this process would run about $40 per ton. Production costs for the new process in a 550-ton per day plant were estimated at about $37.50 per ton in the St. Lawrence River area, and about $46 a ton in the Lake Erie area. This process starts with ore which is first processed and balled on a pelletizing disc, then run through a sintering machine, and finally refined in an electric arc furnace.

A shaking ladle has been built for speedy desulphurization and carburization of high sulphur acid cupola iron. The iron is tapped or poured into the ladle, which is insulated with firebrick and lined with corundum. The ladle is on a turntable, rotated at 60 rpm with an eccentricity of 2.4 in. Because of the motion, turbulence



This direct reduction process has relatively low capital cost.

occurs which gives good mixing action with a lime addition. Three to 15 tons of iron ore can be treated with two per cent lime and in ten minutes the sulphur will be reduced to 0.01 per cent from 0.20 per cent. It is also possible to add coke breeze to raise carbon.

Automation is also being applied to portions of the coke plant. One of the first applications is on the quench car, where the system enables the door machine operator to bring the car to the coke guide by remote control. From there, the cycle is automatic. The car moves under the coke guide at a rate controlled by ram movement, travels to the quench tower, then to the coke wharf, where it dumps the coke. The car then moves away from the wharf and waits to be called again by the door machine operator.

United States Steel Corp., in conjunction with another company, will build a research facility for experimental production of metallurgical coke from noncoking subbituminous coal in Wyoming. The test plant, with a capacity of 250 tons per day, was scheduled for initial operation late in 1960. It will carry on experimental work on an unconventional coking process which has been under development for several years.

Another new technique for making coke uses a rotary hearth furnace which is similar to those used in many metallurgical heating operations. This is a continuous instead of a batch process as in the beehive and by-product processes. By-products may be recovered.

It is reported that the process can use low grade coals. Production furnaces are envisaged as units about 70 ft in diameter, which would produce about 5000 tons of coke a month from about 8000 tons of coal.

McLouth Steel Corp. started production on a 110-ton unit which supplements five other oxygen converters at that plant.

A pilot plant was planned for operation late in 1960 at Dorchester, Va.

The operation of a light oil extraction type dephenolizing plant with contact towers has given good results at the Donner-Hanna plant. Since treating the high phenol tar plant effluent, the main sewer outlet has tested 95 per cent phenol removal. In more than three years operation no maintenance problems have appeared except some corrosion of the valve stems which are to be replaced with stainless.

A pilot plant operated by Inland Steel for the removal of anhydrous ammonia from coke oven gas has shown that the process is feasible and can remove the ammonia from coke oven gas without consuming sulphuric acid. Ammonia of the desired grade of purity can be obtained and the process equipment is commercially available. The process also enables production of either ammonia sulphate or anhydrous ammonia depending on marketing conditions.

A decanter sludge recovery process at Sparrows Point mills the sludge so that individual particles will remain in suspension in tar lines. It is thus possible to supply tar containing more free carbon for combustion in the open hearth, which is a desirable property as far as flame radiation is concerned. The results of the operation have been gratifying. In 1958 an average of almost 50,000 gal per month additional open hearth fuel was produced and in 1959 this went up to 53,500 gal per month. The free carbon in the open hearth fuel has been increased slightly. The cost of operating the sludge reduction plant has been 6.8¢ per gal of product which includes all alterations and improvements. This utilization completely eliminates a considerable disposal problem.

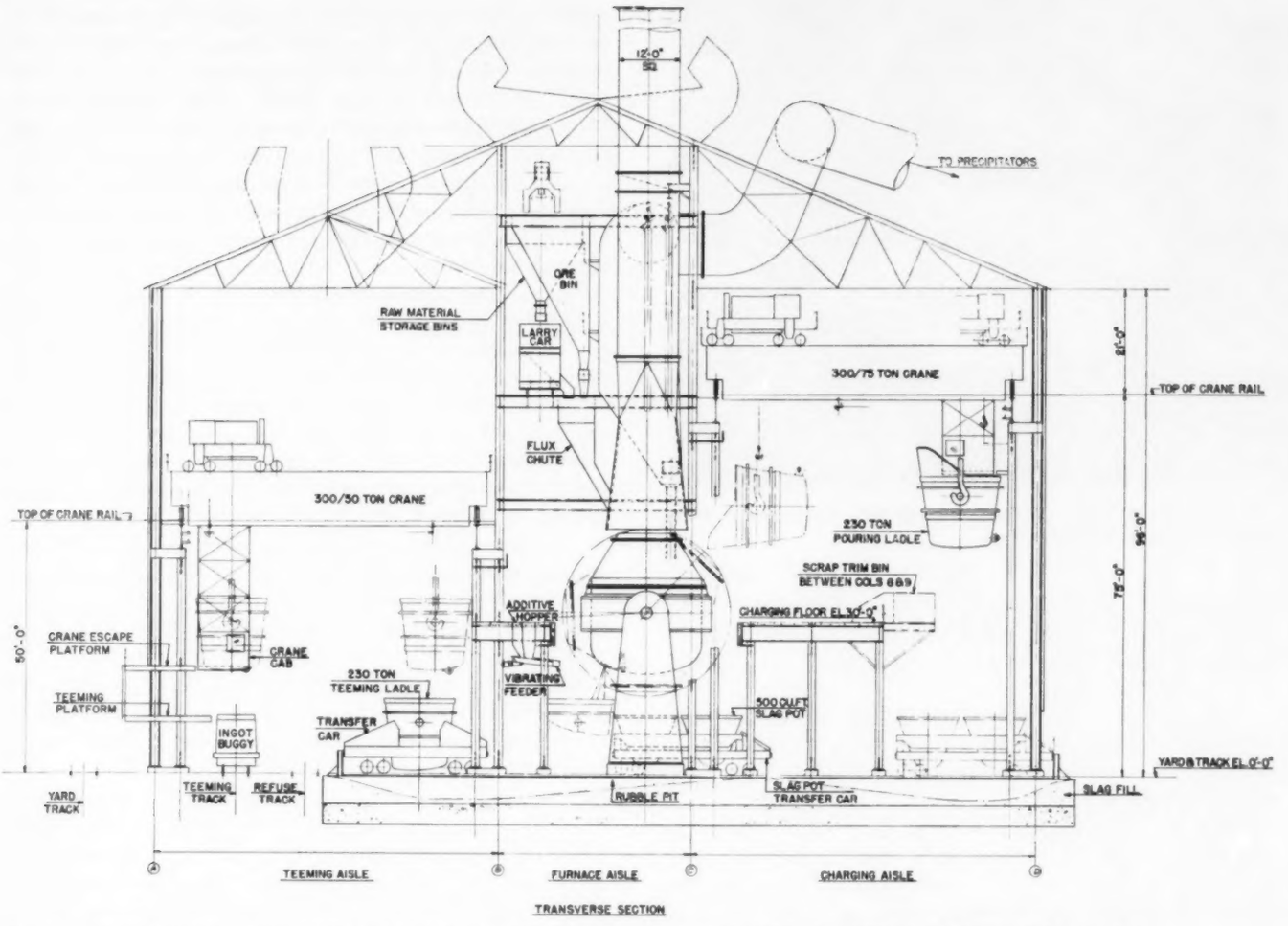
Condemnation of a coke plant holder at Alan Wood Steel Co. brought the problem of building a complete new holder. Instead, an automatic control system was installed, which acts as follows:

1. Maintains gas inlet pressure to compressor or boosters at pressure of 14 in. of water.
2. Provides an automatic system which follows existing operational sequence in loading and unloading the compressor.
3. Provides constant pressure control when on an emergency operation through steam turbine boosters.
4. Provides automatic protection for low or high gas pressures.
5. Gives reliability even greater than that with the conventional holder installation.
6. The changeover was accomplished without any shutdown.

Satisfactory operation has been obtained from this system, which has been in operation since the end of March, 1960.

STEELMAKING

Steelmaking has shown continuous development during the past year, revolving principally around some phase of oxygen use. One striking report from Ford Motor Co., described a steelmaking technique which reportedly can reduce open hearth time by more than one-half. Production of 70 tons per hr on a 200-ton furnace and 105 tons per hr on a 400-ton furnace were reported.



Cross section shows new oxygen converter plant under construction at the Cleveland Works of Jones & Laughlin.

For these production rates, emphasis was on speed of charging. Heats were made with 50 per cent hot metal, extremely high firing rates and extensive use of oxygen. Two oxygen fuel lances are used along with the standard end burners. The fuel in the end burners is bunker C oil and the roof lances use natural gas with oxygen. The lances on the 200-ton furnaces can provide oxygen up to 60,000 cfhr or 30,000 cfhr of natural gas with 48,000 cfhr of oxygen. In charging, scrap density is an important factor. The total charge for the 200-ton furnace is carried in 13 buggies and delivered to the furnace in one drag. Some 6500 lb of burnt lime is spread over the hearth and sandwiched in between the scrap. Maximum firing is going on during the charging at the rate of 14 gal of oil with 5000 cfm of oxygen. The roof lances are inserted about one foot through the roof and furnish some 30,000 cu ft of natural gas mixed with 48,000 cu ft of oxygen per hr. Thus, fuel input totals about 190,000,000 Btu per hr.

After charging, roof lances are lowered to about two ft above the scrap. As the scrap melts down the lances are lowered still further. About ½ hr after charging, the hot metal is added to the furnace. After the refining cycle starts, the natural gas is shut off and only the oxygen at a rate of 48,000 cfhr comes in through the roof lances which are lowered to about four in. above the bath. The total charge-to-tap time runs a little under three hours with heats averaging 198.9 tons, or a rate of 70.2 tons per hr. Total charge-to-tap fuel is about 1,368,000 Btu per ton and total oxygen consumption runs 1575 cu ft per ton.

Despite the promising reports of the process, much research work remains to be done. Development work is underway on the effects of varying the proportions of scrap and on charging ore along with burnt lime.

Work with the oxygen-fuel burner has also been going on at other plants. It is reported that oxygen fuel lances are being built which will handle 60,000,000 Btu of natural gas per hr and even up to 100,000,000 Btu per hr.

Against the increased production afforded by the oxygen-fuel lance are the extra costs involved. A conventional roof lance heat uses about 600 cu ft of pure oxygen per ton, compared with the 1500 cu ft per ton. Also, the use of burnt lime at approximately $20 a ton compared with $4 for limestone means higher costs.

On the other hand, the savings of fuel alone are reported to more than offset the cost of the oxygen, while the increased production is a major saving.

Considerable experimental work has been done with oxy-fuel equipment installed through both the end walls and roof of the open hearth. The oxy-fuel roof lances have a rather wide flare angle, with a flame port angle of 30 degrees from the vertical, and will melt an area from eight to ten ft in diameter. This seems to be a maximum desirable angle, since a further increase in the angle would minimize the jet's effectiveness when operated with oxygen alone.

Jones & Laughlin is using an analog computer to aid their oxygen converter operation.

Oxygen-natural gas ratios of from 1:1 to 2:1 have been studied. It appears that the most effective heating occurs at ratios between 1.5:1 to 2:1, depending on the condition of the scrap.

Future test programs will check the use of pre-mix, face-mix and post-mix burners having firing ranges considerably in excess of the present burners which have been developed.

The use of oxygen-fuel techniques may result in modification of the present open hearth. For example, if all fuel is introduced through the furnace roof, this might eliminate the checker system, in which case the combustion products could be used for waste heat boilers or to preheat scrap. Changes in the geometry of the furnace will undoubtedly occur.

Reports from the Fairless Works on the use of oxygen in the open hearth indicates that, with oxygen, the production rate has gone up from 34.64 tons per hr to 41.26 tons per hr with an oxygen consumption of 445.6 cu ft per ton. With oxygen lancing practice, the charge-to-tap time is 7.28 hr compared with 8.74 for non-oxygen, and the time from tap-to-tap is 8.52 hr compared with 9.97. Fuel used with oxygen is 2,470,000 Btu per ton, compared with 3,310,000 when oxygen is not used. Fairless has standardized on two roof lances per furnace. Lance elevation is controlled from a push-button located on the furnace panel board. Average roof life of basic bricks is twice the life of silica roofs. Electrostatic precipitators clean the open hearth gases effectively.

It is reported that a spring suspension roof design, which permits a free rise and fall of the roof to accommodate varying temperatures, is increasing furnace campaigns at a Pennsylvania steel plant. In this design the roof refractories are hung from a steel framework supported by a coil spring system. The roof is designed to function as a conventional sprung arch. Magnesite-chrome refractories are used.

Proper application of hot patches can help steelmakers get more heats per campaign from the all-basic open hearth furnaces. A slurry mix, mixer and gun combination recently developed permits gradual uniform application of patching material to basic roofs, back walls, port skews, front walls and uptakes. The fine ground refractory material is supplied in a chrome or chrome magnetite base. Both types bond rapidly and develop high strength when properly applied. The patching mix can also be used to maintain suspended end construction below the furnace floor and for sealing end walls or front walls.

Material handling is one of the drawbacks in increasing open hearth production and one of the worst factors is the time needed to charge scrap into the furnaces.

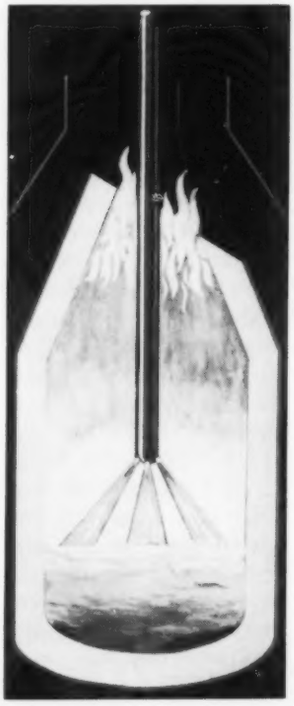
An interesting variation in open hearth design is a 250-ton open hearth furnace without a front wall in operation in Russia. The furnace framework is of all-welded construction and instead of a front wall, there is a single opening, or essentially a long charging area which is 5 ft-9 in. high and 40-ft long with seven water-cooled free hanging doors. The weight of the front portion of the roof is supported by a longitudinal cross beam of the frame.

It was found that this type of furnace can be charged rapidly and uniformly. The worry normally associated with hitting the doors and the front walls was eliminated. One drawback is the high thermal losses from the cooling water.

In Russia, open hearth furnaces of 660-ton capacity were under construction in 1960, and on the design boards were 880-ton units whose capacity can be increased to 1000 tons.

Evaporative cooling is now used on 50 per cent of Russian open hearths, and no new furnaces are being built without such systems. Open hearth furnaces are also built with waste heat boilers. Plans are also underway to combine the recovery boilers of the evaporative cooling system with the waste heat boilers into a single system to raise thermal efficiency.

In a U. S. plant, computers have been used for detailed studies of the effectiveness of factors in metallurgical processes. Several studies have been made on steelmaking with oxygen practice.



Oxy-fuel burners may some day increase the ability of the converter to use scrap.

The Appleby-Frodingham Steel Co. has rebuilt three 300-ton tilting furnaces so practically the whole of the steelmaking operation is accomplished by oxygen lancing. The charge consists of 100 per cent molten iron of 1.0 to 1.25 per cent phosphorus from an active mixer. Oxygen usage is 1270 cu ft and fuel is 820,000 Btu per ton. Production increased 50 per cent over a modern all-basic furnace prior to conversion. The furnaces have waste heat boilers and electrostatic gas cleaning plants. There are two sets of slag chambers and regenerators, so that a changeover can be made without taking the furnace off, increasing operational availability. Thermal utilization when waste heat steam is included is much higher than comparable open hearth practice.

Although the Ajax process is conducted in the hearth of an open hearth furnace, it is for most of its cycle identical in principle with the modern oxygen steelmaking processes. Only during charging and refining does it operate as an open hearth furnace. When tapping is complete, the furnace still contains from 20 to 30 tons of molten steel, and all the refining slag from the previous heat (from 7 to 14 tons). About 12 tons of ore, five tons of limestone or lime are charged and the furnace fettled with dolomite. The molten iron is then brought from the active mixer.

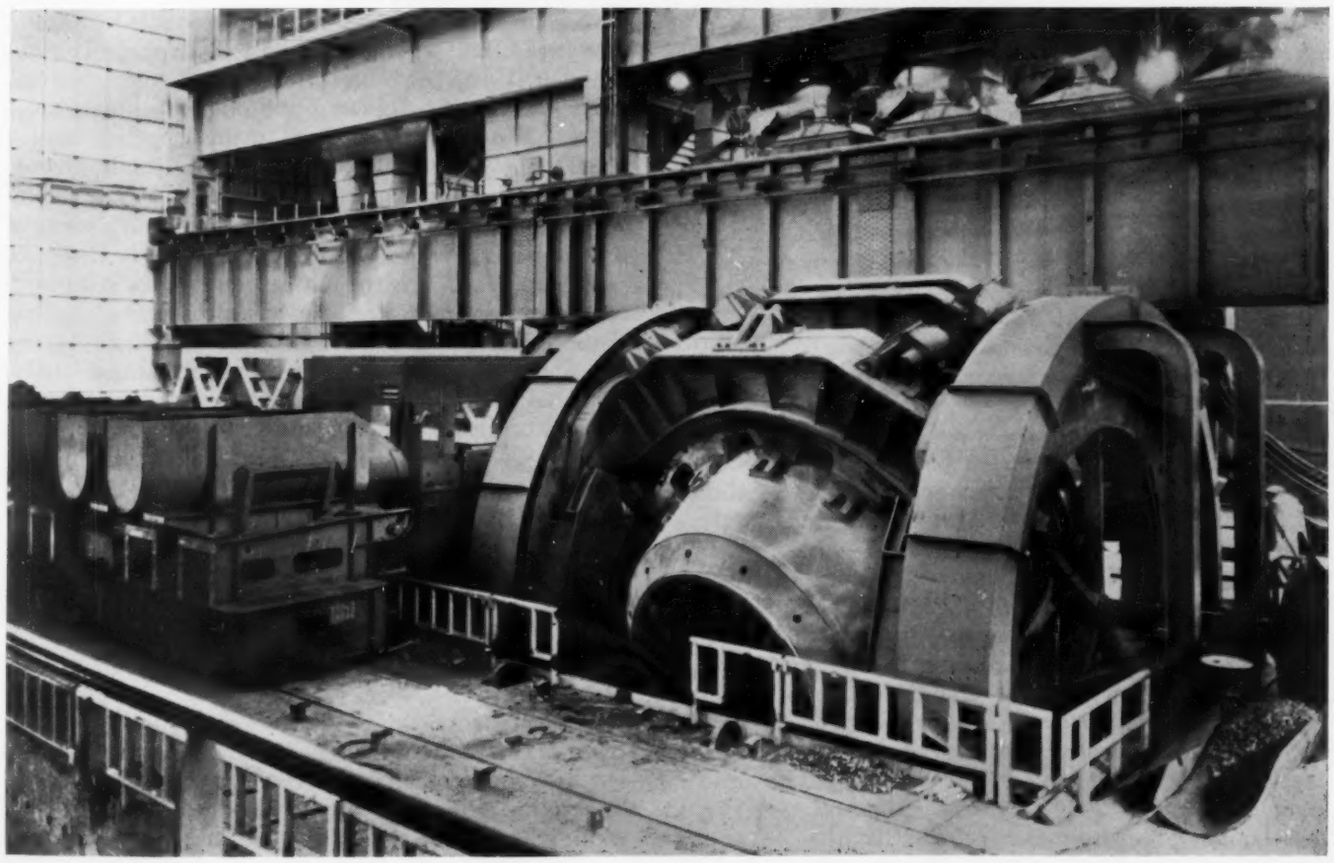
Between tapping and charging the metal, the furnace is fired with coke oven gas and combustion is accelerated by the admission of about 50,000 cfhr of oxygen which enters through two jets just below the coke oven gas inlet in each of the two burners. As soon as charging of the second ladle of molten metal starts, the coke oven gas and combustion oxygen are shut off completely and oxygen for lancing is started at rates up to 75,000 cfhr. The volume of hot air admitted through the regenerator is adjusted to 5.5 times the oxygen volume passing through the lance; thus almost all of the carbon monoxide evolved from the metal is burned in the furnace. The fuel is shut off for the final oxygen blow and when the calculated oxygen volume has been added, a sample is taken for complete analysis.

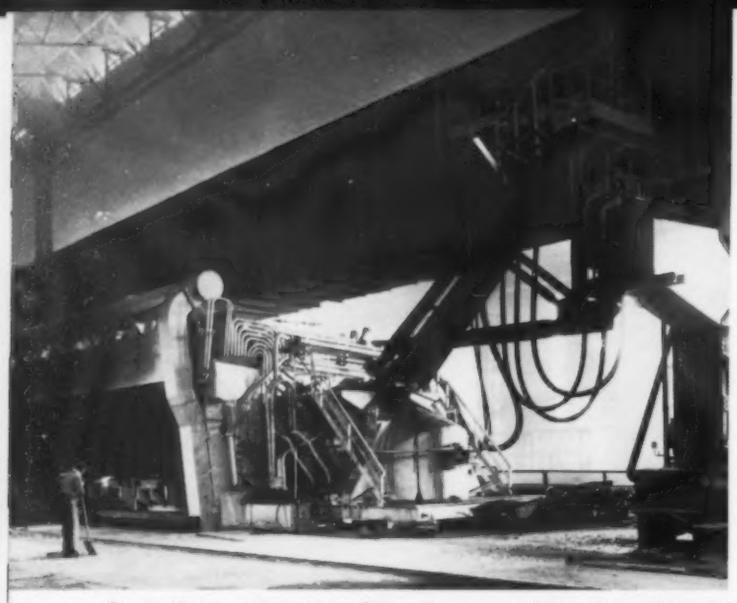
Since the process combines to a certain degree both the open hearth and the oxygen converter, it has the advantages of the open hearth furnace for finishing the charge, coupled with the advantage of the basic oxygen process for metallurgical refining.

A recently developed Russian oxygen process is said to combine some of the features of the rotor converter and the Ajax furnace. One unit, started around the end of 1958, is built to pilot scale with a capacity of 15 tons. The lancing system has a primary and a secondary jet with the primary jet immersed in the bath at a depth of up to 4 in. while the secondary jet is some 4 to 8 in. above the bath surface. As in the rotor process, the secondary oxygen is used for burning the carbon monoxide evolved from the bath. The furnace can be rotated at speeds from 0.2 to 1.0 rpm. Oxygen consumption varies with the carbon content of the steel produced, ranging from 1340 cu ft per ton for carbon contents around 0.8 per cent up to 1640 cu ft per ton for a final carbon content below 0.3.

At the present time it is estimated that there are top-blown oxygen converters in some 15 countries with a total world annual capacity of over 15,500,000 tons. Of these, 17 units with an annual capacity of 5,597,000 tons are in operation in United States and Canada.

Initial reports from Sollac's Kaldo operation have been favorable.





Operations with the Ajax furnace show low thermal demands.

Five of these, with an annual capacity of 1,440,000 tons, are in Canada. The remainder are in the United States. With the new larger units under construction, it will be possible to get production tonnages from converters of over 200 tons per hr. The input oxygen rate is the key factor; the maximum rate now possible is about 100 cfm per ton of charge with present lance design. This rate is in common use and therefore most converters take the same time for heats regardless of the size of the heat.

New top-blown oxygen converter installations are under construction throughout the world. Scheduled to be in operation by the end of 1960 were some 60 vessels with capacities up to 160 tons.

The Russians report that, at the Petrovskii Works, for the first time in their country, full scale production of top-blown oxygen converter steel is underway.

The Koninklijke Nederlandsche Hoogovens en Staalfabrieken, n.V., Ijumiden, Holland, is replacing two 66-net ton top-blown oxygen converters with three new 110-ton vessels. The job should be done before the end of 1961.

Construction was started May 3 on an oxygen steelmaking plant at the Pueblo plant of The Colorado Fuel and Iron Corp. This installation will have a capacity of 50,000 to 70,000 ingot tons per month. This will be a 2-vessel plant, each rated at 100 tons. The vessels will be 27-ft high, have an inside diameter of 18 ft-6 in., with a neck opening 6 ft-6 in. in diameter. One vessel will operate at a time, with the other in the lining dock.

An on-site oxygen producing plant will be built in Pueblo to feed the new oxygen converters and for other steelmaking purposes. This unit will be able to supply 270 tons of oxygen per day.

McLouth Steel Corp. put into operation a 110-ton top-blown oxygen converter in April, 1960. This unit has a unique right-angle water-cooled smoke hood. Limitations in existing plant height made this unique design necessary. The new vessel is in addition to two other 110-ton units, and three 60-ton converters.

Great Lakes Steel Corp. awarded contracts in November for their new plant at Ecorse, which will have an annual capacity of 2,000,000 tons. Plant will have two 300-ton units, the largest now scheduled.

One indication of the value of top-blown oxygen converters evident during the year was that the operating rate of such units was usually higher than the over-all steelmaking rate. Perhaps no better criteria can be shown on the relative economy of this process compared to other steelmaking methods.

There have been a number of new techniques in oxygen steelmaking. It is reported that high phosphorus hot metal can be used in the converter. For this, the Japanese have used a single-slag process which they call a "soft" blowing. A more typical pattern, however, is a 2-slag technique. With such a technique, when the metal bath reaches a carbon content between 1½ and 2 per cent, the phosphorus content is under 0.3 per cent. At this point the blowing is interrupted and the first slag, which is relatively high in phosphorus, is removed and fresh lime and fluxes are added. The blowing is continued until the desired final point is reached. Then, the steel is tapped and the second slag, relatively low in phosphorus, is used for the next heat. It is reported that hot metal containing as much as 1.5 per cent phosphorus can be refined in this manner.

Another new technique is the use of a high grade ore for cooling, instead of scrap. Tap-to-tap time is shorter because it is easier to add ore through chutes than scrap in the conventional manner. There is also a saving of up to 10 per cent in oxygen.

Work is also underway on bottom blowing of converters with oxygen. One process reduces the iron oxide fume markedly. High pressure oxygen is injected in the bottom of the metal bath through special injectors. There is no need for external cooling of the injectors because of the cooling effect of the oxygen flow itself. With a deep bath, the oxygen efficiency is high and the iron oxide fumes are reduced to a minimum. The exact oxygen pressure to be used is not set but it seems that a minimum of 400 psi is necessary to avoid burnoff. With higher temperatures, the pressures may have to be higher. Heats have been treated with over 1200 psi of oxygen. If the process proves practical, it may also lead to quite radical variations in the vessel design itself. This work is an extension of the desiliconizing procedures discussed in previous years.

A valuable aid to operating the top-blown oxygen converter has been developed by the Jones & Laughlin Steel Corp. A set of mathematical equations was derived from thermo-chemical principles which can be used to compute thermally balanced charges for the furnace. By using controlled charges, a larger percentage of the heats can be turned down within the specific tapping temperature range than would otherwise be possible. The charges were first calculated by a specially designed slide rule type computer designed from a mathematical model. An electric computer is still better suited, and such a unit was put into operation late in the year. The number of off-temperature heats have been reduced appreciably.

New computer calculates the proper proportions of hot metal, scrap and lime to be charged into the furnace so that the steel may be tapped at the desired temperature. Procedure is normally used on 0.05 carbon steel. To compute the charge for heated steel, the melter sets the computer's potentiometers for the desired charge weight, tap temperature, basicity ratio, lance height, scale and ore additions, plus measured values of iron

silicon, iron manganese, and iron temperature. The advance control button then is pressed. The computer then prints all inputs on paper tape. After the print operation which takes five seconds, the control button advances the computer to the compute position where the control equations are solved for the given input conditions. The operator pushes the control button three more times, and computer displays in turn the desired quantities of scrap, hot metal and lime.

There are possibilities also that the new oxygen fuel burner may not be limited to the open hearth. By introducing such a burner into the top-blown oxygen converter, present limitations on the maxium permissible amount of scrap may be removed, provided the side effects on the refractories do not make it uneconomical.

Lining life for oxygen converters has been excellent at the Fontana Works with the use of a new tar-bonded refractory for the inner lining. Some 277 heats with a total tonnage of 30,625 tons of steel have been obtained with such a lining.

The Consett Iron Co. Ltd., in England announced plans for a new plant which will combine both the LD and Kaldo oxygen steelmaking processes. There will be two 100-ton LD units and two 100-ton Kaldo units. Production is expected by the end of 1961. The plant is designed to produce 750,000 tons annually. The selection of the two processes was to fill a need for a very wide range of products. Plans contemplate producing the low carbon steels in the LD units, and the medium, high carbon and special grades in the Kaldo units.

The operating reports on the Kaldo units at Sollac plant for the first four months operation showed that the heats averaged 125 net tons with an average oxygen consumption of about 2100 cu ft per net ton. Charges ran 61 per cent iron and 39 per cent scrap. Lime consumption was 200 lb and ferroalloys 10 lb per net ton. Typical early heats indicate that hot metal with initial 1.75 per cent phosphorus will give a final steel with phosphorus and sulphur each below 0.015 per cent and nitrogen less than 0.002 per cent. During the heat, a slag-off is used.

There were strong rumors during the year that one American steel company was on the verge of authorizing a Kaldo steelmaking plant.

An LD-AC furnace installation is to be installed at the August-Thyssen-Huette plant at Duisburg-Hamborn, Germany. This plant will eventually consist of six 110-net ton furnaces and will process high phosphorus pig iron. The initial installation will consist of two furnaces with a combined yearly capacity of 750,000 tons. The vessels will be 20-ft inside diameter and about 31-ft high. The first two furnaces will be in operation by the fall of 1961.

Two other LD-AC plants were an individual 66-net ton unit for the Huettenwerk Salzgitter Works scheduled for operation in the summer of 1960, and another 44-ton unit for the Mannesmann Huettenwerke.

The OLP process for top blowing with oxygen and powdered lime is in operation at Dillingen in the Saar where a 30-ton converter is in use on high phosphorus iron. In the fall, a 60-ton OLP converter was started at Usinor's plant in Denain. A second unit of the same size was scheduled for startup by the end of 1960.

Continuous casting has made more rapid headway in Europe than in the United States.

The new Dunkirk plant in France will have a 140-ton converter which will use the OLP process.

A large electric arc furnace shop is to be built in England for the Steel, Peech and Tozer Works of the United Steel Companies, Ltd., Sheffield, England. There will be two 165-ton, 40,000-kva electric arc furnaces, in the first phase of a 5-year, $25,000,000 modernization program. The plant's annual ingot capacity will be raised to 1,480,000 net tons, to make it probably the largest electric steelmaking plant in the world. Some 21 open hearth furnaces in two shops will eventually be replaced with six large electric furnaces.

Reasons behind this move are interesting. Hot metal for Steel, Peech and Tozer came from Appleby-Frodingham, both of which are divisions of United Steel Companies, Ltd. The development of the previously mentioned Ajax process at Appleby-Frodingham, with its 100 per cent hot metal charge, indicated a shortage of hot metal for Steel, Peech and Tozer. An over-all study showed that production economy would be improved by adoption of the Ajax process at Appleby, and with all scrap going to electric furnaces at Steel, Peech and Tozer. Reports indicate that, with the same ratio of scrap and iron in the two plants combined, significant cost savings result.

There is a continuing trend to the installation of vacuum melting equipment with higher capacity, and to the installation of vacuum degassing equipment. Ingot weights up to 30,000 lb are possible and ingot diameters up to 32 in. maximum can be obtained at the present time.

In January, Midvale-Heppenstall Co. announced that they will build the world's largest consumable vacuum arc melting furnace, designed to melt ingots up to 40 in. in diameter and weighing up to 50,000 lb. Projected annual capacity of the furnace is 8000 tons. Design of the unit will permit experimentation in the casting of ingots up to 60 in. in diameter.

In February Allegheny Ludlum Steel Corp. announced that it would build at the Watervliet works, a consumable electrode vacuum melting furnace which, with some modifications, could produce ingots of more than 60,000 lb.

An effective method of removing hydrogen from molten metal was developed in Canada, involving bubbling an inert gas through the molten bath. When the bubble rises to the surface of the metal, both inert gas and hydrogen escape at the same time.

It differs from other processes in that the inert gas enters the molten bath through the bottom of the ladle through a porous refractory plug which is part of the ladle bottom. This plug is pervious to gases but not to molten metal. The gases most commonly used are nitrogen and argon, although active gases are sometimes used. Since nitrogen enjoys a cost advantage over argon, it is used wherever possible. However, in the case of molten steel, argon is recommended as the flushing gas to avoid the formation of nitrides, whereas nitrogen is used for flushing aluminum or copper alloys. Typical consumptions of the gas are four to six cu ft per ton of steel.

An exothermic sideboard which is placed inside steel ingot molds reduces size of cavity to be cropped. As a result of the extra heat supplied by these boards, ingot yields have been increased. Results from the Brackenridge plant of Allegheny Ludlum Steel Corp. show that yield has increased five per cent from ingot to slab with the sideboards, and the yield from ingot to finished product has increased even more. The use of the sideboards also eliminates the crane service needed for hot tops.

Pressure treatment of teeming ladle nozzles with a hot tar solution is said to reduce bore erosion and spalling. The tar is charged into the nozzles in an autoclave which has been first evacuated. After a pressure cycle with tar, the cylinder is again evacuated and the nozzles are exposed to superheated steam.

In the continuous casting field, a new 4-stand continuous casting plant is to be installed at the Appleby-Frodingham Steel Co. at Scunthorpe, England. This new unit will be equipped to cast four strands of blooms, 9-in. square, and will operate from 100-ton ladles with a weekly production capacity of 5000 tons. Operation is scheduled to start December, 1961.

At the end of March a vertical continuous casting plant was put into operation at the Industrias del Besos, S.A., Barcelona, Spain. This unit is designed to produce carbon steel billets in sizes from 2 × 2 to 4 × 4 in. and 8 × 2⅜ in. slabs. Ladle has a capacity of 15 tons.

A vertical continuous casting unit is also to be built for the Aktiengesellschaft der Dillinger Huettenwerke. This plant will provide for the production of slabs up to 60 × 8 in. to serve as starting material for the manufacture of plate and strip. The plant is scheduled to go into operation early in 1961.

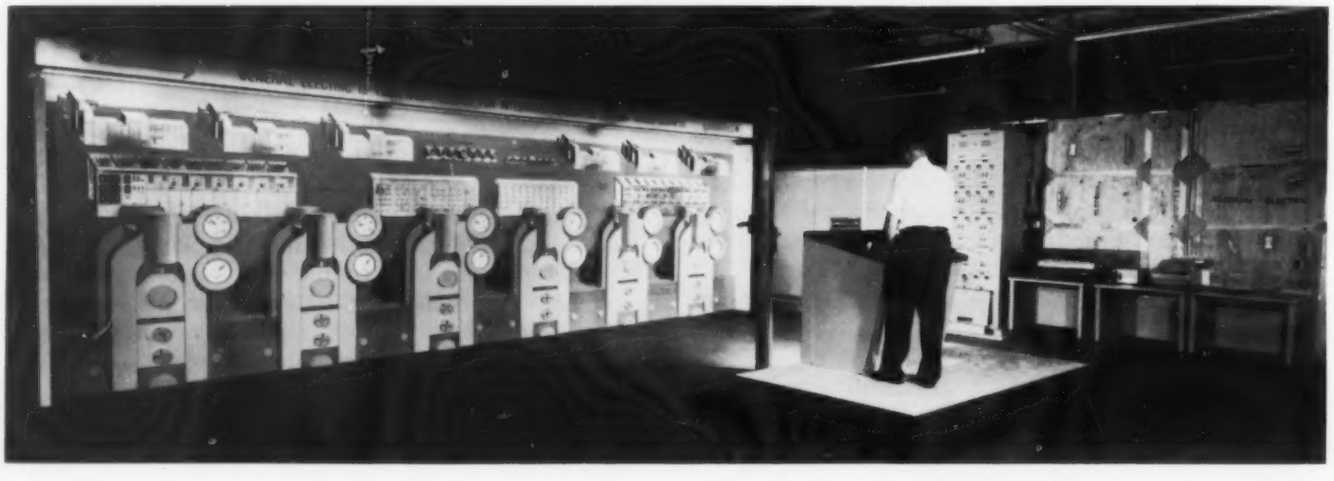
The Benteler continuous casting plant at Schloss Neuhaus/Paderborn has been revamped so that monthly production capacity will be 6000 tons. This now is a dual strand line which can produce 4¾ and 5½-in. square billets, and 17¾ × 2½-in. slabs. Eventual capacity will be up to 11,000 tons a month of these products.

Russians report that they are making extensive use of continuous casting for producing wide slabs and a variety of square section billets. A number of two and 4-pass units are under construction or in operation.

There has been a great deal of interest in the pressure pouring of semi-finished steel shapes to eliminate the need for soaking pits, blooming mills and other such equipment. The ladle containing the molten steel is placed in an air-tight chamber and as the air pressure in this chamber is increased, metal from the bottom of the ladle is forced upwards through a refractory pouring tube and into the graphite mold located above the chamber. When the mold cavity is filled, a refractory plunger shuts off the metal flow and the mold is removed from the chamber. The unused metal returns to the ladle and the plunger, which is expendable, remains in the casting. The use of graphite molds gives close dimensional tolerances on the castings.

The procedure has been used to cast several semi-finished shapes in a variety of materials, such as stain-

An operating model of an automatic hot mill met with a great deal of interest at the annual AISE exposition.



less and carbon-steel alloys, boron steels, and nonferrous materials. Slabs, billets and tube rounds have also been tried. It is reported that speeds are high and that a 30-ft billet, 4-in. square can be poured in about ten seconds, after which the mold can be removed in four to five minutes. It is also reported that defects in the semi-finished shapes are rare, and no scarfing or machining is necessary before rolling. Some center-line shrinkage has been noted in some cases, but these seem to weld up suitably during rolling.

ROLLING MILLS

In the rolling mill area, a great deal of current emphasis is on hot strip mills. A number of design trends are evident in the new installations. The new mills are being built with higher horsepower drives than ever before and 6000 to 8000-hp stand drives are in evidence. These are normally double-armature motors and the rectifier power supply is usually made up of two units in parallel.

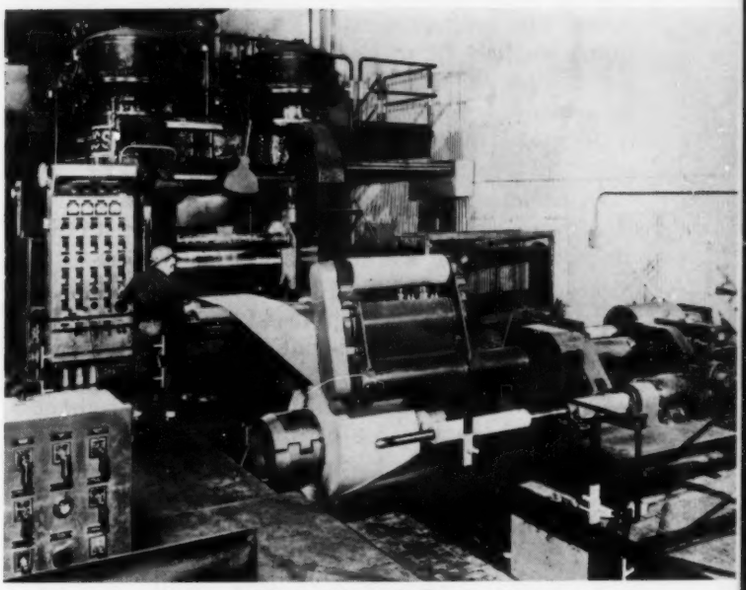
Speed regulators are now also accepted as standard equipment on a hot mill, and the use of silicon controlled rectifier firing circuit for the pumpless ignitron rectifier has given the newer speed regulators fast response.

Under construction is what is believed to be the first electro-hydraulic system for operating screws on a hot mill. This system uses hydraulics for the power supply for the prime actuator and is controlled by electrical regulators. Advantages of the electro-hydraulic system over an adjustable voltage drive system include faster response and higher ratio of torque to inertia. The result is a drive system which is about three times more effective in making screw changes to correct for thickness deviations.

In the system, the output of the gagemeter amplifiers is fed to the force motor coil of a high-flow, fast-response servo valve. This valve controls the flow of fluid into the main cylinder and thereby controls the positions of the screws in response to the signal from the gagemeter control. The valve time constant is about 0.03 sec for small flow changes. Short as this is, it is still the longest time constant in the system. A bank of accumulators is used instead of a pump to supply the high flow requirements. A smaller pump stand keeps the accumulators charged.

A new looper is hydraulically operated and so designed that the ratio of looper cylinder force to strip tension is a constant independent of the looper position. When used to hold constant intra-stand tension, a position feedback unit is located at the looper pivot to provide a signal to either the preceding or succeeding stand drive speed regulators to keep the looper roll within its normal operating range. In effect, the looper, when used with this speed tie, keeps the mill stands together without operator attention. The loopers can be used to hold constant low interstand tensions which will reduce width deviations and reduce the tail end gage increase resulting from loss of tension as the strip tail leaves the mill stands. It is reported that six new or revamped mills will have hydraulic tensiometer loopers.

One reason for the interest in hydraulic loopers is that experimental work and analysis of records taken of gage



Stainless department of Gary Sheet & Tin put into operation a new temper mill which will handle strip up to 50-in. wide.

variation on coils rolled on continuous hot strip mills show there are three major changes in gage: first, a rapid decrease at the front of the coil, followed by a slow increase in thickness along the length of the coil, and finally a rapid increase in the last 100 ft. The main reason for these variations is a differential between the finishing speed of the last roughing stand and the entrance speed of the first finisher which causes variation in temperature and therefore in the yield stress along the length of the coil. The second reason for variation is the variations of applied strip tension. If the mill is operated with raised looper rollers and at constant small interstand tension, the strip is rolled with a steady increase in gage from front to back due to temperature changes, but without the rapid gage change at each end. If the loopers are not used, rapid changes in gage at the front and back of the coil occur as tension is applied and released from the coil, much of it brought on by the droop of the mill motors.

The rolling of the lighter gages for the automotive market at high speeds creates a problem in keeping the front end of the strip on the runout tables at speeds over 1800 fpm. Since the new mills have in several cases speed capacities for rolling as high as 3000 fpm, this problem must be overcome. A mill speedup function has been added which permits the mill to run at a relatively low entry speed until the front end of the strip reaches the downcoiler. At the instant the strip is snubbed on the mandrel, the speed automatically accelerates to a higher speed, with as great as 25 per cent speed change in as little as five seconds. The mill continues to roll at the higher speed until the tail end of the slab starts through when the stand is automatically dropped down to entry speed. This design reduces thermal rundown of the slab with the shorter rolling time, and longer slabs can be rolled without exceeding the maximum allowable time for the slab in the mill.

Computer control in hot strip mills is expected to increase output tonnage by reducing cobbles, by faster mill setup time, more even distribution of load between the mill stands and by giving savings in operating ex-

pense. The savings in expense may be possible due to using smaller crews, less experienced operators, or elimination of manual record keeping. Other gains by the computer control are improvements in product quality and more complete production records which help management spot problems quickly.

In modern hot strip mill design there is a tendency to aim for slab and coil weights running up to about 1000 lb per in. of width. This will lead to outputs on a semi-continuous mill of 2,000,000 to 2,500,000 tons per year, and perhaps up to 4,000,000 tons on continuous units. In a semi-continuous mill, the breakdown should be not less than one in. thick and this leads to a minimum installation for large slab practice of six finishers. Because of furnace limitations, maximum slab length is generally about 30 ft. Hence, slab thickness must be about 10 in. to obtain 1000 lb per in. of width. This is also about the maximum thickness that can be rolled to hot band gages in 11 passes.

With the continuous mill there should be enough room in an installation to have at least five 32-ft wide reheating furnaces to realize the mill's tonnage potential. In these furnaces, five heating zones are becoming the accepted norm. This has the advantage of giving proper soaking practice and minimizing differential heating.

The new Great Lakes Steel Corp.'s 80-in. hot strip mill involves some of the latest design thoughts in such equipment and also represents one of the most automatic units now under construction. The four furnaces for this mill will have 100-ft effective hearth length, a chamber width above the skid lines of 32 ft, and will have about 250 tons per hr heating capacity. This design is based on Great Lakes' conclusion that 160 lb per sq ft per hr of heating capacity is a maximum heating rate which could produce a good quality product.

Upon reviewing the various designs, it was decided that maximum flexibility and firing control would be available with a 5-zone furnace equipped with holding burners with each zone being individually controlled. The furnace would have a total of 487,000,000 Btu per hr available, of which 267,000,000 Btu per hr is from the top soaking and holding zones.

Some of the basic features of these furnaces are a 27-ft hearth with four hearth rails and four 5-in. water cooled furnace skids. Metallic recuperators will be used on the furnaces and all furnaces will have automatic controls for air-fuel ratios, temperatures and pressures. The control is so designed that the furnaces can be computer controlled.

The mill is designed for a finishing speed of 3000 fpm. There will be seven finishing stands, each of which will use 60-in. diam backup rolls and 28½-in. diam work rolls. Mill housings will have 1000 sq in. post areas. The use of the seventh finishing stand enables maintenance work on any one stand without substantially detracting from mill production capacity.

The roughing train has a 1500-hp scalebreaker, one 2-high roughing stand, and four 4-high roughing stands. In the roughing train, there are two 5000-hp motors and three 10,000-hp motors on the horizontal rolls. In the 7-stand, 4-high finishing train there are two 7000-hp and five 8000-hp d-c motors. This horsepower capacity, with high speed, makes it possible to operate at rated mill capacity in the lightest gages at about 54 in. wide.

The finishing train of this mill will have an automatic gage control system that will adjust for gage variations in the sheets. The system is based on strain gages located on the bottom chord of each housing in all of the finishing stands. These strain gages report to computers the loads that exist. In addition, the strain gages on No. 2 through No. 6 finishing stands are in the automatic gage loop.

On this mill there will be water headers for roll cooling with pressures up to 250 psi. The operators feel that effective cooling of the rolls will minimize the requirements made on the gage control system. There will also be a double set of high pressure descaling headers on the first three finishing stands which will develop pressures up to 1500 psi.

The run-out tables are 470 ft long and have eight banks of top and bottom sprays with the bottom sprays operating at 60 psi and the top at pressures up to 200 psi, if necessary. These sprays are also computer activated.

The mill will have three retractable 2-roll coilers which can be removed from under the coiler table. This mandrel driven coiler will have a 300-hp motor and will form a 72-in. outside diameter coil around a 20½-in. diam shaft.

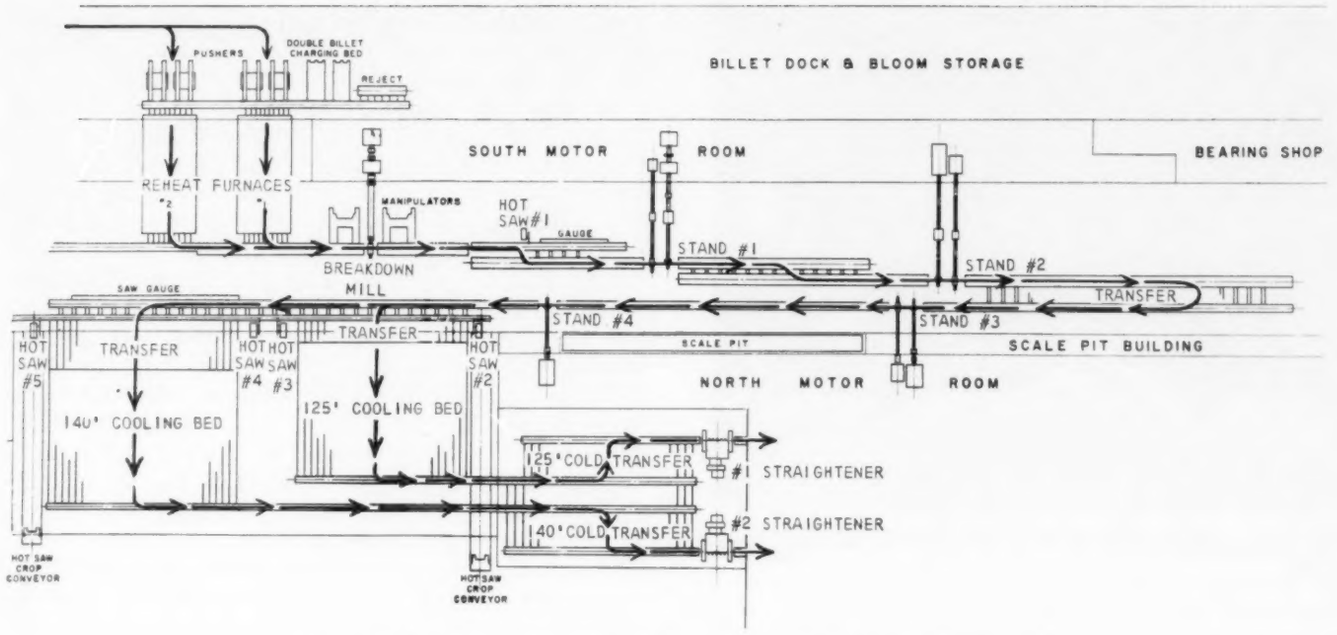
Over 200 points of sensing and positioning are involved in the control setup, and there was a need in the design for thousands of memory units.

The furnace data will be logged but not controlled. All units from the main edger side guides on through the weighing scale will be computer-controlled or logged or both.

The computer operation will be as follows: A rolling schedule will be supplied by the planning group to the mill by tape and duplicate slab inventory cards identifying each slab. These cards will be placed in sequence. The computer first picks up the slab location at the first sensing station at the entering guides to the vertical edgers, and thereafter at 11 more points down the mill train. These points simply identify the location of the slab.

Positioning controls in the roughing mill respond so rapidly that two slabs, each requiring different settings, can be processed through the roughing mills at the same time. The roughing train will be set through two portable strain gages placed between the top and bottom rolls at each end after roll changes. The mill rolls will be brought together until a definite and equal pressure is noted on the portable strain gages which set the mill and establish a zero point from which the computer can set the required roll opening. On the finishing stands after roll change, the mill rolls will be faced off against a definite pressure, but the computer monitoring this action adjusts each screw so that identical pressures are indicated on both ends of the mill.

The computer will monitor readings and adjust mill settings between slabs on the roughing stands. In essence, once the computer is completely programmed, the essential information the computer will need will be entry slab thickness and width, thickness at the No. 5 roughing stand, and final gage and width. Any element of the operation can be taken off the computer control



Layout of 34-in. structural mill at South Works of United States Steel.

and set on manual adjustment, and returned to automatic. The data logging of the slab information, as well as the final coil weight, is written on the typewriter.

A very interesting feature in the guarantee on the automatic digital computer system states that this unit will have an operational availability of 99 per cent in a 6-month reliability test.

In essence, this system is a completely transistorized general-purpose digital computer with a magnetic core memory which will control all operations of the hot strip mill from the time the slabs enter the line at one end until they come out as coils at the other end. The computer will operate at a rate of 44,000 computations a minute.

The mill will also have a recording profilometer which will check strip quality and find ridges as they start to show. With this gage, transfer sample strips are cut from the hot bands as they come from the mill. The profilometer is then run along the strip sample and the profile is obtained in from one to 1½ min.

A new hot mill, which will be the largest unit in Europe, is under construction in Russia at the Novo-Kramatorsk plant. This mill will roll strip from 39 to 93-in. wide in thicknesses from 0.06 to 0.47 in. from slabs running from 4½ to 6-in. thick and six to 18 ft long, in both carbon and alloy steel. Finishing speed will be 2400 fpm. This mill consists of ten stands, two scalebreakers, flying shears, three coilers, etc.

In the cold rolling field, great emphasis was directed at the possibilities of rolling thin tinplate. Although the proportion of the tinplate market which has been taken by aluminum is still very small percentagewise, it has increased very appreciably from month to month, and the aluminum manufacturers have made no bones about the fact that they plan to capture an appreciable portion of this market. Price cuts on aluminum flat products during the year were significant.

In one answer to this challenge, the steel industry is concentrating efforts on the rolling of thin tinplate. Much pilot work is under way and canmakers were trying this product to determine canmaking characteristics. Very few results have been announced except in generalities.

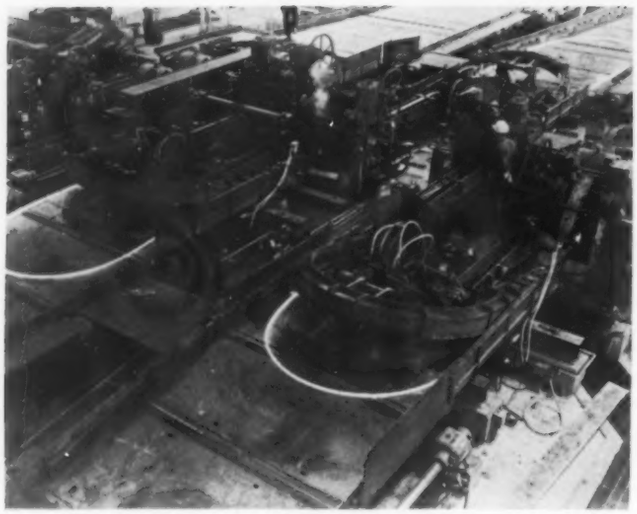
However, the development work is apparently going in three directions. One way is to roll strip on a regular tandem cold mill down to ordinary gages, and then reroll the strip on a sendzimir mill to gages down as far as the 0.004-in. range. This procedure requires extra handling of the coils and some people question the ability of the sendzimir mill to roll successfully at the high speeds of up to 3500 fpm under consideration. An installation of this type will be in operation soon at Granite City Steel Co.

A second approach to the problem will be through the installation of very powerful 6-stand cold tandem mills. One of these was ordered by Youngstown Sheet and Tube Co. for its Indiana Harbor Works and another has been ordered by Tennesee Coal & Iron. In these mills, the extra power will give the reduction needed, and the extra stand will help production speed. With these mills it will also be possible to dummy a stand for use in conventional rolling. One drawback of the 6 or 7-stand mill is that, unless speeds are markedly increased, tonnage is inversely proportional to the thickness of the strip.

The third approach is through conventional reduction on a four or 5-stand cold mill, tinning the coil and subsequent reduction in a single or 2-stand temper mill.

It is rumored that there are problems in the roll bite since at these thin gages the mill will probably be rolling on face, and perhaps lubricant and rolling oil problems must be solved. There may also be heat and other problems generated in the thin strip to which the best solutions have not yet been found. The temper mills may also be used to reduce the strip before coating.

Shipment of the world's first 6-stand, 4-high tandem cold reduction mill at the Indiana Harbor Works of Youngstown Sheet and Tube Co. was made in August. This 52-in. mill will have speeds up to 7250 fpm. When installation is completed, the mill will cold roll steel



New bar mill at Ceco Steel is designed for flexible operation.

strip in widths up to 46 in. and deliver coils 80 in. in diameter, weighing over 62,000 lb. The mill has a total of 34,900 hp for the main drives, which is believed to be the largest application of power on a cold reduction mill.

The United States Steel Corp.'s Tennesee Coal & Iron Div., will install a 6-stand, 52-in. tandem cold strip mill at Fairfield, Ala., with total drive horsepower of 32,100 from 12 motors. This mill will have a 2000-hp motor on stand No. 1, two 2600-hp motors in a twin-drive on stand No. 2, two 2500-hp motors for a twin-drive on stand No. 3, two 3000-hp, double-armature motors in a twin drive for stand No. 4, two 3000-hp, double-armature motors for a twin drive on stand No. 5, and two 35000-hp, twin-drive double-armature motors for stand No. 6. A 2100-hp motor will drive the tension reel.

United States Steel Corp. is the only company so far to market the thinner tinplate. The material is commercially available in weights of 45 through 60 lb per base box, or about half the thickness of tinplate conventionally used in canmaking.

The next unit expected to be in commercial production will probably be Granite City Steel Co. Coils from a tandem mill will be rerolled on a 40 in., wide nonreversing sendzimir mill, driven by a 4000-hp, double-armature, 600-volt, 500/750-rpm drive motor. Payoff reel will be run by a 1200-hp, double-armature, 300/-1080-rpm drag generator, and the winding reel will have 1200-hp, double-armature 185/835-rpm motor. Included with the mill are automatic gage control and new load regulating tensiometers using strain gages on the housing. Power for the unit is furnished by a synchronous motor-generator set with two 1600-kw generators, one 1000-kw generator; a 1000-kw, 750-volt generator previously purchased will also be used and a 5500-hp synchronous motor. The main drive control will have a 400-cycle magnetic amplifier on the main generator fields and 60-cycle magnetic amplifier controls for the motor fields with all static excitation.

On this operation, the 4-stand cold mill, which was revamped several years ago, produces strip at 0.015 in. at 3500 fpm. In order to get additional tonnage, the sendzimir mill will take the 0.015-in. thick full hard material from the tandem cold mill and reduce it one pass to the 0.008-in. standard tinplate thickness and also the extra thin gages probably down to 0.0044 in.

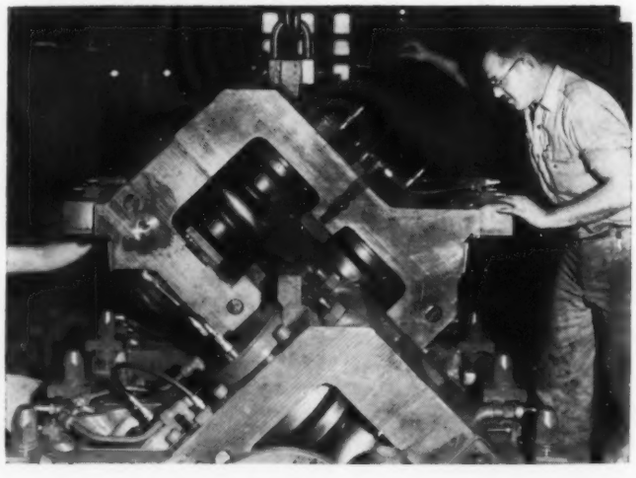
Another new cold mill will be the 52-in., 5-stand tandem cold strip mill to be installed at Midwest Steel Corp., Div. of National Steel Corp. The drive on stand No. 5 is a 7000-hp, twin motor drive consisting of two 3 x 1165-hp, 200/500-rpm, 750-volt triple-armature motors connected to the mill working rolls through one to two ratio step-up gears. This gives the stand a speed range of about 2410/6025 fpm with 23-in. diam rolls, and will allow normal operation at 5000 to 5500 fpm on tinplate. Stands No. 2 and 3 have two 2500-hp, twin drive motors each. Stand No. 4 has two 3000-hp, twin drive motors, and stand No. 1 has two 1500-hp, twin drive motors. The reel has two 1800-hp, triple-armature, twin drive motors. Drive capacity of the entire mill is 29,600 hp. An all-static 400-cycle magnetic amplifier regulating system provides accuracy, speed of response, forcing and stability of the mill. Stand No. 1 and stand No. 5 are controlled by an automatic gage control system. Two x-ray gages control screwdown adjustment of stand No. 1 and tension of stand No. 5.

An ingenious idea in cold strip rolling which may increase strip production by as much as 10 per cent is a slowdown unit which automatically counts the turns on reversing cold strip mill reels during coiling and uncoiling. This equipment automatically determines the latest safe point to slow down the mill for reversing. This eliminates the possibility that the strip can snatch off the uncoiling reel with consequent damage and loss of time, and increases production since full speed is maintained for a maximum time.

A new installation at United States Steel's sheet and tin mill, Gary, Ind., is a 34 x 76-in. temper mill. This unit will act as a scalebreaker to accelerate pickling, and will be an integral part of the new continuous pickling line. Strip from 18 to 60 in. in width can be handled.

All blooming mills operating in Russia are reported to be 2-high reversing with roll diameters of 32½ to 47 in. There are two, 2-stand blooming mills with series layout of the stands. The Russians claim that the blooming mill at Kuznetsk and Magnitogorsk Works have capacities much higher than 3,000,000 tons a year and claim this is higher than those in the United States. Automatic

Downtime is reduced in new tube mill which permits removal of roll housing as a unit.



control has been applied to some mechanisms on some of the mills. The Russians plan to increase roll diameters of bloomers to 51 in.

Russia has six rail and structural steel mills with tandem layouts in operation.

The new automated structural and finishing mill at the South Works of United States Steel is a very versatile unit. The layout consists of a 53-in., 2-high reversing blooming mill with a card programmed control system which gives complete automatic control of the rolling operation from predetermined schedules. The mill produces slabs up to 52-in. wide x 8-in. thick and blooms from 6 x 6 up to 20 x 20-in. square. Driven by two 6000-hp motors, it has a maximum delivery speed of 1120 fpm.

The 34-in. secondary mill includes two 5-zone reheating furnaces with capacities up to 150 tons per hr. These furnaces are followed by a 40-in., 2-high reversing breakdown mill featuring individual drive motors with 4000 hp on each roll. The 34-in. structural mill proper is semi-continuous, arranged in a double hairpin type with two stands in each line. The first and second stands are reversing and the last two are single pass, unidirectional. The setup of the structural mill when rolling wide flange sections includes No. 1, 2 and 3 stands as a universal and edging stand combination, and No. 4 finishing stand, a single universal type. When rolling shapes, the universal stands are replaced by single horizontal stands and the edging stands are replaced with a movable table section.

The mill features highly automatic control. The three reversing stands use card programmed control of horizontal, vertical and edger roll screw positioning, product manipulation and positioning, main drive and table entry and rolling speeds, mill and table reversal, twin drive speed ratio control, mill and edger draft compensation, bloom reentry, schedule identification and many other auxiliary functions.

The breakdown mill and the first finishing stands have the first application of twin drives to mills which are rolling unsymmetrical products. The application was made possible by accurate, fast response speed ratio regulators which maintain desired top to bottom roll speed ratio during transient disturbances. The desired ratios cover a 30 per cent plus or minus range and are established by instructions on the control card or by settings of individual pass potentiometers. The breakdown mill producing beam blanks may require 90 to 180-degree turns of the partially shaped product. These are provided automatically by instructions presented on the punched card direct to the side guard and finger motions.

An interesting setup for measuring steel structural members with a noncontact system uses closed circuit television. One such unit has been installed in a large eastern rolling mill where it measures I-beams as they are cut to length at the hot shear. In this system the I-beam and an illuminated scale are viewed by a television camera and the length is read out on a monitor screen. Tests show that beam lengths up to 36 ft can be cut with an accuracy of $\pm \frac{1}{8}$ in.

Two trends may affect future production of structural steel. Work is underway on the development of new structural beams 40, 42 and 48 in. deep with thinner webs to give better utilization of the steel properties. Another development is the adoption by ASTM last summer of a new A-36 steel which will primarily be used in structural and plate items. This material is similar to the A-7 but has a yield strength of 36,000 psi, compared with the 33,000 for A-7 steel.

Computer program control will be installed on United States Steel Corp.'s plate mill in Gary. This mill consists of a 2-high scalebreaking stand and a 160/210-in. reversing plate mill which will handle slabs ranging from 3 to 24-in. thick, 48 to 75-in. wide, 54 to 264-in. long, and up to 70,000 lb in weight. The finished plate will range up from $\frac{3}{16}$-in. thick, 198-in. wide and 45 to 125-ft long. To change from 160 to 210-in. width, housings will be shifted on sliding shoeplates.

The control on this mill features a combination of card programming, computing and correction monitoring by means of roll force and x-ray thickness measurements to produce plate within close tolerance of specified thickness, width and length. The punched-card digital input to the computer programming control will be minimal, consisting of incoming slab width, thickness, length, grade of steel. Also required are the outside plate width, length and thickness. The computer will determine the number and sequence of passes, settings of screwdowns, guides, table feeds and spraying operation. The computer will control feedback information to correct for product dimensional deviations. Most mills of this type have been previously powered by flywheel or synchronous motor-generator sets. This particular unit will have a converter-inverter ignitron arrangement which will supply power to the drive motors with the proper voltage polarities needed for reversing service and will permit regeneration of power.

The reversing mill will be driven by 12,000-hp, twin-motor drive consisting of two 6000-hp, 40/80-rpm, 800-volt motors with the conventional arrangement of top roll motor back. The drive will be powered by two 5000-kw, 800-volt rectifier power supplies with pumped type ignitron rectifier tube assemblies. A 3000-hp synchronous motor will drive the horizontal scalebreaker which precedes the main stand. Total horsepower is about 36,000. The control will use 400 cps magnetic amplifier regulators.

An automatically controlled reversing plate mill with two vertical edgers was shipped to Republic Steel Corp.'s Gadsden Works. Upon completion, this mill will roll reheated slabs into plate up to 126-in. wide and also operate as a reversing rougher for the hot strip mill.

The mill will have completely automatic operation by means of a card-programmed system when reducing slabs for rolling in the hot strip mill finishing stands. The punch card system will control the speed and roll openings of the two vertical edgers and the plate mill, the reversing of mill tables and rolls, sideguard adjustments and descaling sprays. When the mill is scheduled to roll wide skelp, the slab is rolled broadside. The tapered rollers for turning the slab are manually operated, but all other operations are automatically controlled.

What is believed to be the first mechanized bar mill engineered exclusively to direct roll electric furnace steel ingots into finished bars is in operation at Ceco Steel Product's new plant at Lemont, Ill. This plant is

National Tube put a new continuous butt-weld mill in operation at Lorain.

a semi-integrated cold metal shop with an annual capacity of 180,000 tons. The rolling mill facility includes a billet reheating furnace rated at 40 tons an hr. The mill is a 15-stand unit ranging from a 20-in. roughing stand down to 10-in. finishing stands. There is a 200-ft long mechanical cooling bed, gaging and weighing devices, intermediate conveying tables, bar turning and repeating equipment. Ingots are cast in billet sizes ranging from 322 up to 990 lb. The mill will roll plain rounds $\frac{3}{8}$ to $2\frac{1}{2}$ in. in diameter, plain squares $\frac{3}{8}$ to $2\frac{1}{2}$ in., deformed reinforcing bars $\frac{3}{8}$ to 2 in., flats 1 x $\frac{1}{4}$ to 4 x 1 in., and angles from 1 x 1 x $\frac{1}{8}$ to 4 x 4 x $\frac{1}{2}$ in.

Republic Steel Corp. is installing new facilities at the Canton Works for rolling specialty bars. The complete rolling facility will consist of 18 stands in a semi-continuous train of which there will be 12 straight-away roughing and intermediate stands, three cross-country stands, and three-in-line finishing stands. To insure maximum on-gage product on the short order specialty items, high gain speed regulators were used in all drive motor fields. This will allow repetitive accuracy of motor speed settings when changing product, and minimize stretch and overfill due to impact speed drop.

The product will be finished either to pouring reels or to the cooling bed. The cooling bed product will be held to accurate cut lengths by a new shear which has digital and fully static control.

An interesting design now under construction has roll stands which can be exchanged automatically for another stand. The exchangeable stands are prepared beforehand on special roll changing rigs, and are mounted on traversing carriages ready for use. As soon as the rolls in operation have been stopped, the old stand is detached from its resting place and a shifting piston pushes it onto a traversing carriage. The rolls detach themselves automatically from their drives. All these operations are controlled from a control pulpit by pushbutton. The carriage is then pushed so the new stand comes into the mill line. The hydraulic shifting piston is completely automatic, and can adjust itself in the clamping device of the new stand and pull it into working position. Roll necks are automatically coupled with the drives. Less than five minutes pass between stopping and restarting with the new stands.

It is reported that the Soviet Union is paying a great deal of attention to the development of planetary mills. Although production is not high on such mills, the Russians favor their low weight and economy. They intend to use them in several plants in combination with continuous casting machines.

The Russians are reported to be producing welded tubes with a combination of a planetary hot strip and welded tube mills. In such units, the welding speed of the tube mill is about 390 fpm and the exit speed of the finished tube out of the last reducing stand is about 2400 fpm. Output reaches 250,000 tons per year.

The Russians also are believed to be using new types of planetary mills for rolling 80 to 160 mm (3.15 to 6.30-in.) diam seamless tubes out of stainless and heat resisting alloys and titanium. Such a mill is now in operation at Moscow Tube Works capable of making seamless thinwall tubes up to 100 mm (3.93 in.)

A new 18-stand continuous mill is also being used in Russia for rolling light sections such as angles, etc. Square 39-ft long billets are used in this mill which are

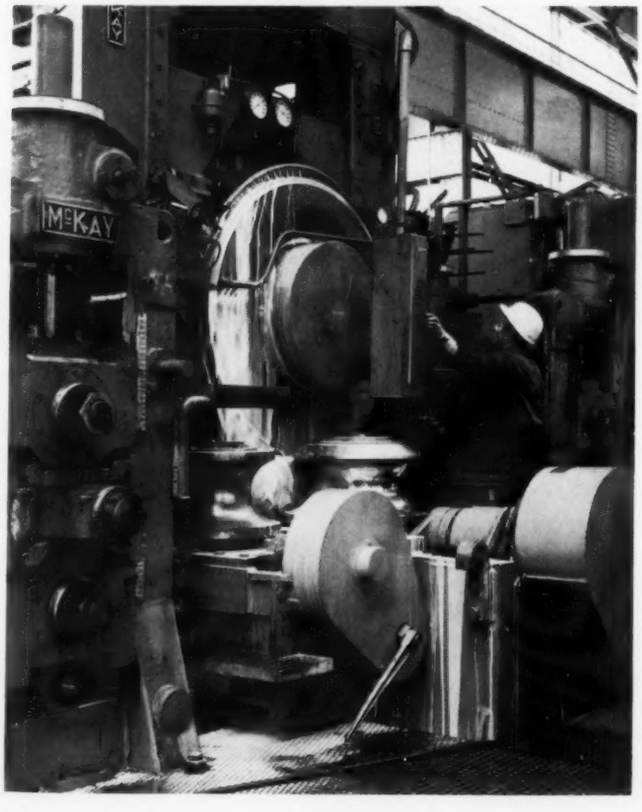
welded after heating but before rolling with a flying buttweld machine into a continuous bar. The maximum speed of the section leaving the last stand is 12 meters per sec or 2360 fpm, and the rated output is 250 tons per hr.

The National Tube Div. of United States Steel Corp. put a new buttweld pipe mill into operation at Lorain, Ohio. The new mill will be able to produce 237,000 tons of pipe annually in sizes from 1¼ to 4 in. The unusual feature of this mill is a hydraulic differential drive system which was mentioned in this report several years ago.

The mill consists of a forming stand, a welding horn, the welding stand where the edges are pressed together, then there are five stands which give diameter and some wall reduction. Following this is a 7-stand stretch reducing mill which brings the welded pipe to its finished size.

Multiple pass rolls allow five pipe sizes to be rolled without roll change. The roll shafts of the stands are 45 degrees from the horizontal and the roll axes on successive stands are perpendicular to each other. The drive system insures compatible speeds for the stands of the forming and welding mill and the stands of the stretch reducing mill. The design is similar to that used in many paper industry applications and allows a 30 per cent acceleration or deceleration of the line, with an accuracy of 0.1 per cent. A 1000-hp, d-c motor drives the forming, welding and reducing stands. With the exception of No. 1 stand, which is positively driven, the remaining stands are powered through differential gear units that are connected to a common lineshaft by right angle gear boxes. The differential gearing permits variation or adjustment of stand speeds without changing the speed of the line shaft.

Electric resistance weld unit shown is rated 160,000 amp and was built in the United States for the Phoenix Rheinrohr works at Dusseldorf, West Germany.



A hydraulic motor drives the differential gearing in the desired direction at the desired speed.

A stretch reducing mill built for Tubes de Acero de Mexico incorporates a number of novel design features. The mill has individual housing units which can be easily removed. The mill rolls thus remain in the housing for the life of the roll and are dressed in the housing with a special roll pass milling machine. This special 16-stand mill will reduce shells of about 6 and 7¼ in. outside diameter to hot finished sizes ranging from 1½ in. standard tube to 5-in. line pipe and casing.

Milling the roll passes with the rolls in the housing assures alinement of the mating roll passes and centering of the roll grooves so they can be placed on the mill housing support base in true relationship with the centerline of the mill pass. Because of elimination of adjustment of rolls and roll housing, minimum downtime is required when changing rolls. It is estimated a complete change on all 16 stands can be made in 30 to 40 min.

During the milling operation the rolls are coupled to a drive which rotates the rolls. After the operation, the sharp corners of the roll passes are removed by the use of a tool fixture mounted on the milling machine opposite from the spindle. The rolls are coupled to a high speed drive for fast rotation for this machine operation.

It is estimated some 12 assembled roll housings can be redressed in nine hours by one roll pass milling machine. This compares with about three hours required to machine two rolls by the conventional method exclusive of roll assembly and disassembly time.

Republic Steel Corp. ordered a 3-stand tube sizing mill for its South Chicago works. The center stand of this mill will be vertical, featuring quick, easy changes. The entire overhead pinion housing for this stand will swing 90 degrees, leaving the mill housing open for removal and replacement. The placement of the pinion stand over the roll eliminates the need for a pit beneath the roll stand, and keeps scale and roll coolant from falling onto the pinion housing. The two end stands in this mill will be horizontal.

All stands and drives will be raised and lowered vertically by two motor driven wedge adjustments. The bottoms of all tubes passing through the mill will be maintained at a fixed elevation.

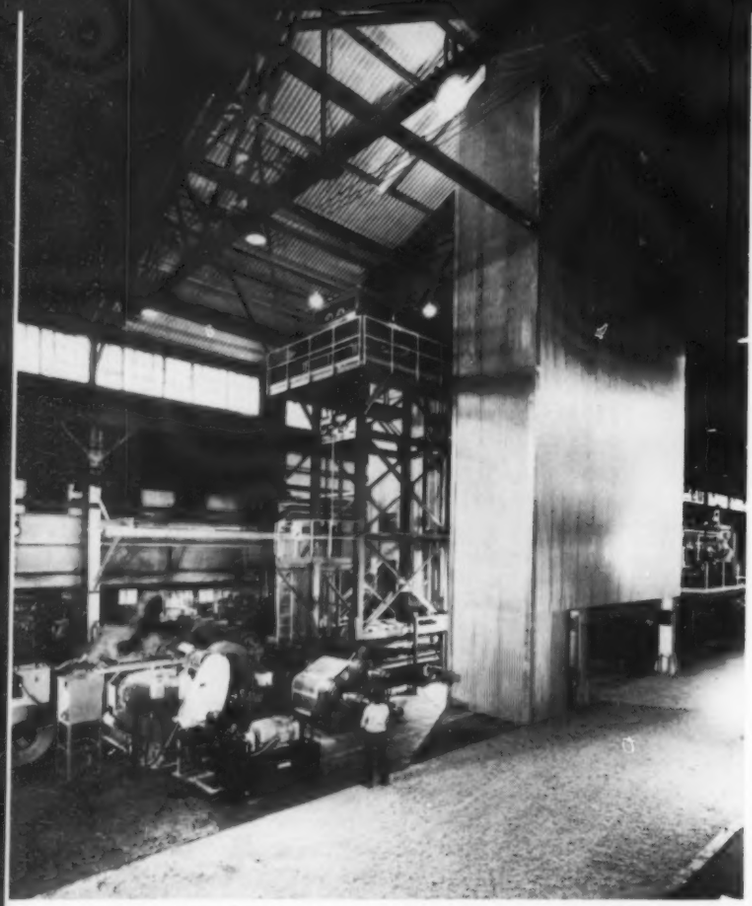
No special tools will be needed to change the vertical and horizontal mill housings, all three of which are interchangeable. A single 500-hp constant speed motor will drive all three stands on the mill.

The mill will handle tubes ranging between 4½ and 10¾ in. in diameter.

A new large pipe mill was put into operation at the Steelton plant of Bethlehem Steel Co. This line will be capable of turning out some 300,000 tons of pipe per year, in size ranges of 18 to 42 in. outside diameter, in lengths up to 40 ft.

A 5700-psi water pressure expander increases the pipe circumference, shortens the pipe length and increases yield strength.

A 191-ft long automatic wire fabric welding machine was installed this year at Keystone Steel & Wire Co., Peoria, Ill. This unit is capable of producing wire mesh at a rate of 60 tons per day. The machine is versatile and embodies quick changeover for various



Allegheny Ludlum put into operation a continuous bright annealing furnace at the West Leechburg Works.

wire diameters and wire spacings. The unit automatically coils rolls of lighter fabric, or when heavy mats are being produced, automatically slits, stacks and transfers the mats for bundling.

A new wire temperature meter which has been recently developed may enable wire drawing at higher speeds. This piece of equipment can measure the temperatures introduced by the drawing in sufficient time so that necessary steps can be taken to control the lubricants for the temperature present.

One roll manufacturer has announced that it will produce its entire line of hardened steel rolls from vacuum cast ingots. It is claimed that vacuum casting reduces the volume of hydrogen and other gases in the ingot to a low level, with the result that the rolls can be forged from sounder, tougher ingots, with little possibility of flaking or micro-cracking.

It is reported that automation will also be applied to roll dressing. A new unit under development will inspect a worn roll and decide how deep it needs to be dressed. This information will be recorded and fed to the control system. Tapes will then direct the turning operation.

There has been a great deal of development of continuous testing equipment. National Tube Div., of United States Steel installed a continuous fluoroscoping process to detect hidden flaws in welded seams of steel pipe. The unit has been in operation at the National works since 1959. Formerly, the pipe was checked by x-ray but only the end portions received this treatment, and the development of film is a drawback on the standard x-ray process. In the new operation the x-ray head of the unit is mounted on a long boom which fits inside the pipe in line with the welded seam. The image is projected on a fluorescent screen. The image is enlarged electronically, picked up by a television camera and relayed to a screen in an inspection control booth. Inside the booth the inspector controls the pipe movement and if a flaw is detected, he marks the spot by pressing a button which releases a paint mark.

Another application of x-ray is the investigation of hot billets in the rolling mill, using a betatron as a radiation source and an x-ray image intensifier in a closed circuit television system for final display. Statistical analysis of equipment indicates that the x-ray screening will find 50 per cent of all the 3-mm blow holes and 90 per cent of all 7-mm blow holes.

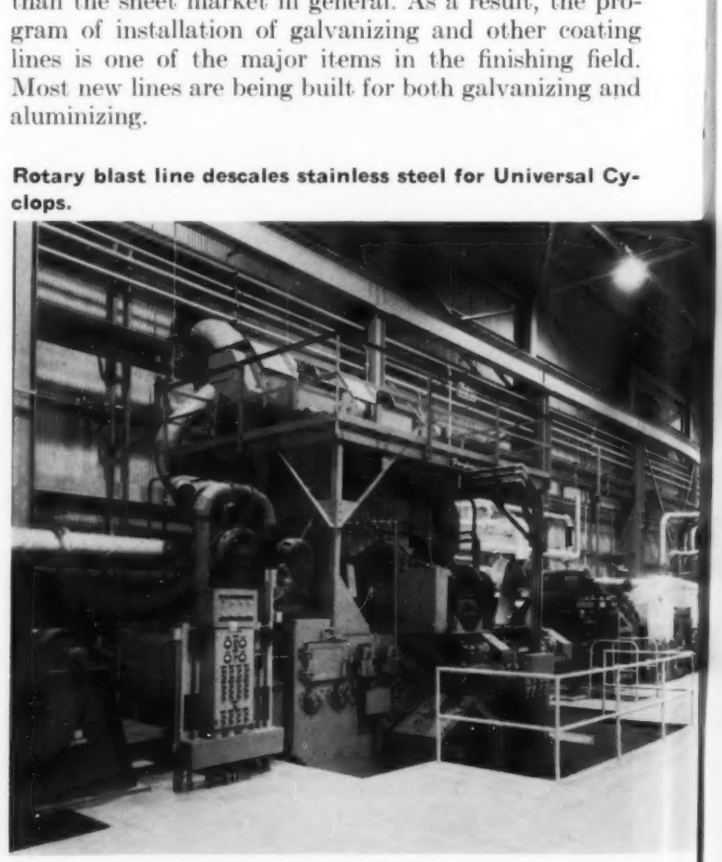
Another approach on inspection is an immersion ultrasonic unit which has replaced most of the contact testing methods at Timken Roller Bearing, Steel & Tube Div. This consists of a 30-ft testing tank which can handle sections up to 12-in. square or 11-in. in diameter. With the procedure, round bars and seamless tubing are rotated as the search unit travels the length of the tank in which the item to be inspected is immersed. An oscilloscope screen is used for noting efect signals.

A new $1,500,000 tube round conditioning installation was completed at Algoma Steel. An integral part of this installation is an inspection unit which checks for defects under black light. The inspection tanks contain fluorescent magnetic particles suspended in conditioned water. The particles coat the rounds, with defects indicated by the particle pattern. An operator marks defect indications with a chalk. Two additional installations are scheduled for American plants.

FINISHING

Present trends indicate that the markets for galvanized and aluminized materials are growing faster than the sheet market in general. As a result, the program of installation of galvanizing and other coating lines is one of the major items in the finishing field. Most new lines are being built for both galvanizing and aluminizing.

Rotary blast line descales stainless steel for Universal Cyclops.



In such lines the trend has been towards wider units which can run at higher speeds and which will process greater tonnages of strip per hour. For example, Armco is building a unit at Middletown, to be in operation early in 1961, which will handle product 30 to 72-in. wide, producing 30 tons per hr. Speed range will be 38 to 300 fpm.

The following is a list of the galvanizing lines under construction in 1960.

Company	Location	Startup	Galvanizing and/or aluminizing
Armco Steel Corp.	Middletown, Ohio	Late 1960	72-In. galvanizing and/or aluminizing
Dominion Foundries & Steel Ltd.	Hamilton, Ont.	June 1960	50-In. galvanizing and/or aluminizing
Granite City Steel Co.	Granite City, Ill.	Early 1961	Galvanizing
Inland Steel Co.	Indiana Harbor, Ind.	Early 1961	60-In. galvanizing and/or aluminizing
Midwest Steel Corp. Div. of National Steel Corp.	Portage, Ind.	1961	48-In. galvanizing
The Steel Co. of Canada, Ltd.	Hamilton, Ont.	Completed June, 1960	50-In. galvanizing
Youngstown Sheet and Tube Co.	Indiana Harbor, Ind.	Middle 1961	48-In. galvanizing

With these new ones completed, there will be over forty galvanizing units of which about 35 are used only for galvanizing, and about seven can be used for galvanizing or aluminizing.

In electrolytic tinning one of the largest installations is that being built by the Jones & Laughlin Steel Corp. at their Aliquippa plant. This will be another halogen type line, supplementing the existing halogen lines and replacing an alkaline tinning line which has been in service since 1943. One of the features of the new line is a looping tower which will permit full speed operation during the welding cycle. The line has a high frequency brightening process. An innovation is horizontal pickling on two levels in order to reduce the floor space required. The new line thus will be 275-ft long compared with 456-ft for J&L's No. 3 line, which is similar except for this feature. Product to be handled will consist of strip in widths ranging from 18 through 37 in.

Perhaps the most outstanding developments in the finishing field are the various installations for data logging and programming finishing lines. One rather interesting instrument for measuring strip moving at speeds as high as 800 fpm is a noncontacting electronic tachometer. This type of unit can replace the conventional roll driven models, and since there is no contact has the advantage of not marking the strip. The unit can also measure strip elongation in mills. This type of tachometer is not affected by such items as roll wear which require corrections in some designs based on counting roll revolutions.

The system is operated by applying an initial magnetic pulse which produces a magnetized area on the strip. This pulse is picked up by a second transducer located at the fixed distance from the first point. This pickup unit senses the pulse and triggers an electronic counter and also triggers another unit which drives the recording transducer. At the same time a second magnetized area is put on the strip and this action is repeated as the strip goes through the mill. The lineal counts and the distance is a measure of the speed of the unit. If inspection gages detect any defects, these are noted by a signal which is induced by the defect. These are recorded and the data can both give the total amount of defects and also their location.

The new data acquisition system which J&L is using for classifying tinplate coils at the Aliquippa works is quite interesting. When operating at speeds up to 2000 fpm, the automatic inspection system can both grade the coils and record such data as total coil length, length of prime material, seconds and waste tinplate. The unit is completely transistorized. Gages which are tied in with this line include x-ray strip thickness gages, pinhole detectors, photoelectric surface detector gages, top and bottom tin coating thickness gages. A footage meter also records the various lengths. The final and summary data from this unit are fed into an electrical typewriter and card punch which provide permanent records for visual inspection or computer analysis. This particular unit has a length gage which is based on a pulse type footage meter which supplies the basic coil length data to the system. The meter gives one output pulse per foot of tinplate.

Another interesting gage is an infra-red sensing gage in use at the Butler plant of Armco Steel. This gage is used for measuring the width of the steel and is actuated by the infrared rays radiating from hot steel. It operates at speeds up to 2000 fpm. The gage will operate when the strip edge is below the color range as long as the temperature is above 900 F. The gage is so designed that sidewise strip movements of as much as 3 in. on each side will not affect the accuracy and there are no adverse effects when these changes are introduced.

Another gage used for automatic classification is a unit which continuously measures the thickness of the sheet by means of one or two x-ray gages placed on opposite sides of a conveyor. As the sheets go by, an average thickness reading is taken, the signal being relayed to a console which sends out impulses to a marking unit which will stamp the appropriate gage at preset intervals along the length. Changes in measurement are instantly registered to reflect the thickness of the sheet to be stamped. This material is then sorted into bins at the end of the conveyor which has flaps arranged to open individually upon signal from the control unit. The design is such that sheets will slide under the proper flap, stacking themselves in the bin by gage thicknesses.

An American company installed an automatic sheet metal grader. This machine is fully automatic and, in addition to automatic selection, pallet supply, positioning, disengaging and unloading are all automatic operations. The only manual handling involved is removal of loaded pallets. The machine is capable of handling sheets 18 x 24 to 44 x 38 in. at a rate of 175 sheets a minute and will carry pallet loads up to 9000 lb.

In the pickling and cleaning field, ultrasonic units

have now reached a point where they can be applied on a large scale. Some of the future potential applications are continuous strip cleaning and pickling of bar stock and wire. It is reported that under some conditions, the addition of ultrasonic units to a pickling installation can reduce the time for pickling to one-tenth of the time for a straight acid type unit with the same acid concentration. It is also reported that it is possible to use ultrasonic cleaning on installations which at present combine pickling with shot blasting. In this case an ultrasonic cleaning tank can replace the pickling portion of the cycle. The flash pickling needed to remove the markings of shot blast residue has been a drawback.

The removal of the smudge which is left after the shot blasting is particularly important on any blast-descaled strip that is intended for cold rolling, cold forming and hot dip zinc galvanizing. Ultrasonic cleaning seems to be particularly effective for removing this smudge.

Some details of one design are as follows. The tank containing the ultrasonic equipment is located close to the exit end of the blast descaling machine. This tank contains a horizontal channel formed by two walls of barium titanate transducers between which the strip passes. The transducer channel is submerged in a highly alkaline wetting fluid which is circulated through a heater. The fluid provides proper cavitation for optimum cleaning action. The immersion time in the ultrasonic bath runs from two to four seconds. Following the ultrasonic tank is a small steam and hot water bath and a forced air dryer.

A new procedure used at Bethlehem for controlling strip pickling bath composition has resulted in acid savings which have paid off the investment and equipment in less than a year. The first control scheme was put on the pickling line at Sparrows Point in 1956, and was initially used for recording bath characteristics for about four months. Automatic control has been used since March, 1957. At present, Sparrows Point is using similar equipment on three other pickling lines, and are equipping the remaining three strip pickling lines. The Lackawanna plant is putting a similar unit into operation and expects to equip the other two lines at this plant.

A given pickling solution can have only one iron content and one free acid content for a given specific gravity and conductivity. Gravity and conductivity sensitive instruments can be set to control automatic makeup of acid to maintain the desired bath composition. As a result, some 10 to 25 per cent less acid is consumed and pickling is much more uniform. Pollution may also be reduced by automatic control of the strip pickling bath composition.

An adaption of electric membrane process for desalting water can be applied to sulphuric acid pickling solutions to reclaim the acid and to collect the iron which has been picked up in the descaling operation.

A method of repairing pickling tanks uses a neoprene troweling compound which is pumped directly through the opening in the steel tank after which the neoprene cures to a plug which stops the leak.

One research group reports that it may be possible to clad metal by extrusion. The process has the advantages of close dimensional control, strong bond between core and cladding material. The cladding does not have to be the same contour as the core, and shapes can be cladded. In this process, core material is passed through a hollow mandrel converging upon a die. The mandrel is housed inside a chamber containing rams that are used to extrude the cladding material. The cladding material is forced through ports located in the chamber between the terminal end of the mandrel and the die. Thus, both the core and the cladding material pass through the die simultaneously. Both core and cladding are heated in the extrusion chamber.

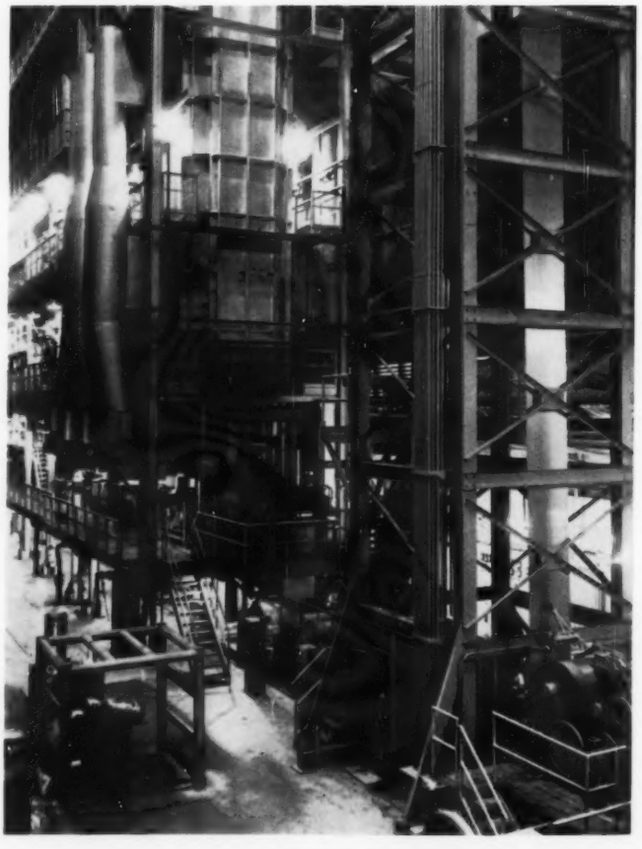
The Air Force Air Research and Development Command reported that they are coating steel with a vapor-deposited aluminum. This development is significant because it enables coating complicated shapes. Vaporized tri-isobutyl aluminum is decomposed at 500 F to cover parts suspended in the vapor with a layer of pure aluminum.

FURNACES AND CONTROL

A development which promises to have an important effect on steel industry heating practices is the open coil annealing system for sheet and tinplate annealing. Continued research on the process reveals that, in addition to conventional annealing, the process can be used to change the composition of steel. The process exposes the surface of the strip to the atmospheres for as short or as long a time as is necessary to insure that gas-metal reactions proceed to the desired end points.

The potential uses of gas alloying are many and a

The new continuous annealing line at the Aliquippa Works, Jones & Laughlin Steel Corp. is the first to have a computer.



whole family of new steel products can result. Enough research has already been done to prove that a direct-on enameling steel can be produced by open-coil gas alloying. The steel producer need no longer furnish very low carbon, low-metalloid steels, which are expensive to melt and roll.

Other possibilities are that the process may improve magnetic properties and aging characteristics of plain carbon and silicon steels, it may be used to carburize the surface of carbon and alloy steel strip, it may also be used to make soft, easily rolled steels harder and stronger by increasing their carbon and/or nitrogen contents.

Another possibility is production of chromium grades of stainless by chromizing plain carbon steel sheet. The secret of the process is that the coils are opened up enough so that the gas can be easily passed through the separations between the wraps of the coils, enabling them to be heated and cooled very rapidly and uniformly. The slow difficult transfer of the heat through the large mass of the coil to the interior area is eliminated.

As of Fall, 1960, there were some 18 open coil gas alloying installations in use or on order by steel companies in the Free World.

The new continuous annealing line installed in the tinplate department of the Aliquippa Works Div. of Jones & Laughlin has several industry firsts, including the first digital control computer system, the first package control system and the first processing line (tensiometer) regulators.

The rated speed of this line is 1200 fpm with a maximum speed of 2000 fpm. It has an acceleration of 0 to 1200 fpm in 15 sec. The length of the strip in the line is about 4000 ft. Material passes through line in less than two minutes. It will handle coils up to 50,000 lb, measuring 85 in. outside diameter in widths up to 38½ in.

The computer system on this line was designed to perform the functions of process control, data acquisition and logging, production analysis and accounting.

The computer control was superimposed upon conventional line drive control equipment and the annealing furnace zone temperature regulators. Thus the computer directly operates 11 proportional fuel, gas and cooling air valves and two electrical contactors to regulate temperatures within the furnace zone. The design is set up in such a way that any one or all the furnace zones may be controlled by the computer or by conventional recorder controllers.

Initially, the computer receives furnace instructions from punched cards, but eventually it will be programmed from one or perhaps more of the process control loops. For the first possibility the computer will set the optimum temperature of all the 11 furnace zones based upon three items of information: tabulating card information, steel thickness and existing line speed.

The computer, knowing furnace temperatures, will set the optimum line speed. If the line is running below the best production rate, the computer will drive the speed to a higher production level as fast as the furnace conditions will change to permit the increased speed. Eventually the computer will also adjust the line speed and, if necessary, furnace temperatures in relation to measurements obtained from automatic hardness measuring equipment. The ultimate process control will combine the speed and hardness control.

United States Steel Corp., started a new continuous annealing line at the Pittsburg works in Pittsburg, Calif. This line operates at speeds up to 1500 fpm. It will process steel strip ranging up to 38-in. wide and coils up to 42,000 lb. Soaking on this line is done by 1000-kw electrical resistance heating elements.

A new continuous high production furnace for stainless steel strip permits bright annealing at production rates as high or higher than the existing annealing and pickle lines at about 50 per cent lower cost per ton. The furnace prevents the formation of scale on the strip through the use of a very pure and dry (minus 60 F dewpoint) hydrogen or dissociated ammonia atmosphere. The furnace is of vertical construction, reducing the floor space necessary and assuring that minimum tension is placed on the strip during annealing.

In the first downward pass, the strip enters a muffleless heating chamber where it is rapidly heated to annealing temperature by direct radiation from molybdenum heating units. After reaching annealing temperature, the strip moves down into an adjacent cooling chamber where it is rapidly cooled by high-velocity hydrogen or dissociated ammonia. A high velocity jet-cooling system forces the atmosphere against the stainless strip at right angles, and with this design, the atmosphere strikes the strip with a scrubbing action which speeds cooling. The atmosphere is cooled by recirculation through water-to-gas heat exchangers.

Furnaces are furnished in two heights, about 54 and 75 ft high. In annealing type 430 stainless strip, 0.020-in. thick at 2000 F, the furnace can operate at 60 fpm. For 24-in. wide strip, the furnace would have a capacity of 6000 lb per hr. Furnaces are available to process strip in widths of 12, 36 and 48 in.

Some manufacturers which have gone into bright annealing with new annealing lines are Armco Steel Corp. and Wallingford Steel Co., a subsidiary of Allegheny Ludlum Steel Corp., and Allegheny Ludlum also has started a unit.

Jones & Laughlin installed a new stainless steel annealing and pickling line at the Youngstown, Ohio, plant which provides for 3-strand operation of stainless steel. The line is equipped with three uncoilers and can be set to process 8, 12 or 24-in. widths of stainless in three, two or one-strand operation respectively. The uncoiled strip is annealed in a direct gas-fired, catenary-type furnace which is designed to anneal 1200 lb of strip per hr at a temperature of 1550 F. Following the furnace treatment, the strip can be fog quenched, if desired. It then goes into the salt bath descaling tank preparatory to two acid baths in electrolytic pickle tanks.

The Stainless Steel Div., of Jones & Laughlin Steel Corp., is using a continuous barrel type furnace installation to anneal a number of grades of stainless bars. The unit is rated at 2000 lb per hr. The entire barrel furnace line needs only one man for operation. Firing is by natural gas in ceramic-lined, cup-shaped radiant burners.

Interest in electric soaking pits was indicated last year when an American company took over the rights of a European process. Details were covered at the

The open coil process enables alloying of strip steel as well as quick annealing.

AISE Spring Conference. Reinforced rectangular steel casings of the pits are lined with insulation and refractories. Internal brickwork divides pits into cells which hold one or more ingots. Coke-filled silicon carbide troughs which run lengthwise are the resistance heaters and most of the heat is transferred to the ingots via radiation. The power is introduced through the end walls by electrodes.

Four basic types of pits are in use: a single heating element through the center; a double pit with resistors on each side and a solid partition in the center; a 3-resistor pit in which the heating elements are mounted on each side of the chamber, with a third passing through the center; and a 2-resistor pit which applies heat from two elements along the walls to a single row of ingots in the middle.

The pits are particularly useful where the charges are small and where they may be charged cold. They entail less initial capital cost and take less space than conventional installations. The electric pit also lends itself to automatic control, and has advantages in minimizing scale formation. A number of such units have been installed in Europe and South America.

Republic Steel Corp. built new one-way fired soaking pits with metallic recuperators at their Buffalo works. Completion was scheduled for November, 1960.

The West Virginia works of the Connors Steel Div., is the first American steel plant to install a special recuperator developed in Germany. These recuperators consist of towers arranged vertically over the waste gas system. The waste gases enter the inner shell of the tower at its base. Cold combustion air is pumped under pressure to the top of the recuperator where it is forced into the annulus, or ringed space, between the inner and outer shells. The heat is transferred to the inner shell of the recuperator by radiation in the lower portion and by radiation and convection in the upper portion. The temperature of the incoming air is raised to 1000 F when the waste gas temperature is about 1750 F. The recuperators are constructed of alloy steel plate and standard steel shapes. Design is reported to be relatively simple, and as a result, little major maintenance is expected and efficiency should hold up. The recuperators are installed on new soaking pits of single-fired design, with 100-ton ingot capacity each.

The Sheffield Steel Div. of Armco Steel Corp., ordered a continuous heat treat line for heat treating plate up to 160-in. wide. The line, about 500-ft long, consists of a 54-ft charge table, 135-ft hardening furnace, 6-ft conveyor table, 50-ft pressure quench, a 50-ft side transfer car, a 153-ft tempering furnace which can have reversible heating, another 50-ft side transfer car, and a 158-ft conveyor table. The line will be fully automatic and pushbutton supervised from a control room. Capacity will range up to 50,000 lb per hr of normalized plate. The unit is expected to be in full operation early in 1961.

United States Steel Corp., also started a new plate heat treating line at their Homestead District Works. This is the second unit in this plant. The line is approximately the same size as the first unit but is able to provide greater production of heat treated plate due to greater flexibility for handling plate and to improved combustion design. The unit can process plate up to 45-ft long x 156-in. wide and up to 2-in. thick. It consists of a hardening furnace, a tempering furnace and a pressure quench.

United States Steel Corp., also installed seven new vertical furnaces for heat treating electric-power generator rotors. The facilities consist of a quench tower and an upending cradle in addition to the seven new furnaces. They were built for heat treatment of rotors in an upright position after they have been forged and machined.

An interesting heat treating unit has been installed at the Timken Steel & Tube Div., in Canton, Ohio. These are isothermal pits used to heat treat hot blooms. The pits enable the operators to change the crystalline structure of the blooms within a narrow temperature range in a fraction of time formerly required in the unfired pits. Thus they will heat treat ingots in one to two days vs ten to twelve days in unfired pits. Two of the new units were installed in 1959 and a total of eight will be put into operation.

A new thought in heat treatment consists of a fluidized bed which is now making its debut as a heat treat furnace. The furnace consists of a bed of fluidized particles in an insulated container heated by outside sources, such as electrical resistance. The object to be treated is immersed in the fluidized bed which outwardly looks like many other conventional batch type furnaces. At the bottom of the furnace chamber, the bed of fine refractory particles rests on a porous plate. The gas is forced up through the porous plate to agitate the particles. Similar units can be used for quenching.

Some of the advantages claimed for the unit are that the beds provide rapid heat transfer between the heating source and the work object, resulting in low cycle time. The size of the objects to be heated provides no limiting factor. High turbulence in the beds eliminates thermal gradients, thus reducing hot and cold spots.

As a result of an extensive research program sponsored by the Association of Iron and Steel Engineers at Columbia University, a comprehensive method for the thermal design of regenerators has been developed which will enable computing and predicting performance of open hearth regenerators much more simply than could be done before. The procedure is based entirely on thermal considerations and assumes certain conditions of air flow. Assumptions, however, may

introduce errors because of fouling and nonuniform air flow conditions. The errors should be minor in general and computed results should still be much more accurate than by existing procedures. The errors, however, will not be a factor for cases where the designer is primarily interested in what performance can be obtained by additions or changes to existing regenerator systems.

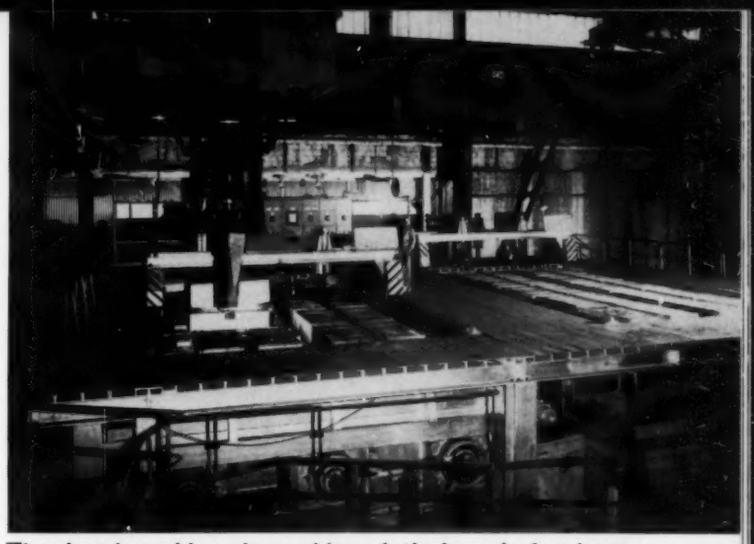
Investigations made by a steel company research laboratory indicates that changes in skid configurations can have an appreciable effect on skid marks. By construction of a mathematical model and analysis, they have come to a conclusion that there is an optimum shape for the skid stagger for any given set of operating conditions, and have developed a method which provides means for evaluation of possible changes in furnace operation or construction in order to minimize the skid marks. Application of these methods should improve slab heating and eliminate some of the variations in gage in hot rolled strip caused by uneven heating.

A new high temperature refractory product which is expected to have wide application is a relatively low cost structural ceramic, high in physical strength, and resistance to attack by heat and molten salt. This is a silicon nitride-bonded refractory which was originally developed for use in aluminum reduction cells.

A new compact and dependable method for producing relatively pure hydrogen at low operating cost and with low initial investment was introduced during the year. Commercial designs have been made for capacities up to 10,000 standard cfhr. This is a 2-stage process in which the first stage dissociates the hydrogen and nitrogen from commercial anhydrous ammonia, using an ammonia dissociator. In the second stage, a continuous cycling adsorption process is used to separate the hydrogen from the nitrogen gas. Either liquid or gaseous ammonia is used in the process.

The application of automated control to many installations has come about only with the development of new instruments for measuring flows. A new integrating flowmeter has been developed which takes accurate measurements of gas or liquid flow even with wide variations of pressure, temperature, density and viscosity. The unit consists of four basic components: a flow-rate sensor, a gyro-integrating mechanism, a cyclometer register and a contact device. The sensor is located in the fluid stream and consists of two cylindrical elements, an impeller and the turbine. Both of these contain channels through which the fluid flows, and the impeller is driven at a constant speed by a synchronous motor (through a magnetic coupling) and imparts an angular velocity to the fluid as it flows through the meter. The value of this angular momentum added to the fluid is proportional to the mass rate of flow. Measurement of this is performed by a second cylinder or turbine placed downstream from the impeller. This second cylinder removes all the angular momentum from the fluid and in so doing receives a torque proportional to the angular momentum. The torque which is proportional to the mass rate of fluid flow is independent of fluctuation in fluid density.

A gyro-integrating mechanism receives this torque through a magnetic coupling and it is applied around the minor-axis of the gyroscope. This causes the gyro to rotate about its major axis at a rate proportional to the torque and thus to the mass rate of fluid flow. The precession or rotation of the gyroscope is transferred through a gear train to the cyclometer register where it is recorded in pounds.



The electric soaking pit provides relatively scale-free heating at surprisingly low power cost.

The gear train output also can act through a contact device which can be used to make and break an electric circuit. Thus it can be used to actuate auxiliary equipment such as totalizers, remote registers, ticket printers, etc. Accuracy is reported to be within one per cent of the indicated value with a repeatability of ± ¼ per cent. Substantial changes in fluid temperature, pressure, density and viscosity have little effect on the metering accuracy.

A new instrument for measuring temperatures is a 2-color pyrometer that measures a ratio of radiation from a heated object at two selected wave lengths or color bands. It can give accurate measurement of temperatures above 1400 F and has been used by one producer to check hot metal temperatures out of the blast furnace. Since the instrument measures a ratio of radiation instead of the absolute radiation level, it is relatively immune to differences in surface emissivity of the material being observed.

It is reported that a combustion indicator is available which will monitor the factors that affect the flame and thus a new approach is made to heat processing control. The instrument is so designed that it will give warning of corrections which may be needed to stop changes in the flame geometry. It can also be set to obtain desired heat values of air-gas mixtures when the fuel gas changes due to enrichment, etc.

MATERIALS HANDLING

In the materials handling field there were no particularly outstanding developments during the year. Expansion in steelmaking and the increased tonnages which can be produced by oxygen steelmaking methods have been limited in many cases by the material handling capabilities of the plant where such new processes are being used. Therefore efforts are being extended to bettering and increasing such material handling capacities.

One operation receiving much attention is the procedure for charging scrap.

In one case, the Jones & Laughlin Steel Corp. has scheduled for their Pittsburgh works, a new type of

scrap charging machine which should reduce charging time appreciably. With this procedure, a special railroad car with a load of scrap is moved into the open hearth on the charging track. The car has mounted on it a magnet jib crane which is used to move the scrap out of the car into a chute from which it slides into the charging box of a conventional charging machine. Magnets are used to orient scrap to prevent pileups. The same charging box on the machine stays on the peel through the charging operation.

At Jones & Laughlin Cleveland works in the new oxygen converter plant, scrap is to be moved into the converter shop on a car with a box which has a right angle chute. As the box is raised, scrap goes down the chute into the vessel. Some 70 tons of scrap can be charged in less than a minute. It is understood that a similar setup will be used in the new converter plant at Colorado Fuel and Iron's Pueblo works.

Noteworthy are the new hydroelectric cranes, applied recently on a number of applications, including several in certain departments of the steel plant.

Most of these cranes are in the class 3 and class 4 categories from structural and duty standpoints and capacities range from 1000 lb to 50 tons, indoors and outdoors. It is reported that they are very safe, for if either power or hydraulic pressure fails, the valves close automatically. The control gives stepless speed ratio range of 200 to 1. The electrical system is simplified and uses standard electrical components. The only moving electrical part is the rotor of the electric motor. Compared with the conventional a-c crane using an eddy current brake, the cost is about the same. One of the reasons for the development of the hydraulic crane is that a study on service calls on cranes showed more than one-half are due to electrical reasons, and of the remainder, most are related to brakes. The objective of the hydraulic portion of the drive was thus to minimize these maintenance problems.

A new type of overhead crane end truck gives full articulation during travel, and thus provides the flexibility usually obtained by floating runway suspensions. The design uses a specially designed ball suspension which gives full articulation to compensate for runway irregularities. This then gives even load distribution and equal loading on all the wheels.

Several new crane rail lubrication systems are expected to increase overhead crane wheel life appreciably. One system is a lubricator produced in West Germany which applies a film of lubricant automatically to the side of the rail without applying any to the top surface. It is reported that this system has increased crane wheel life from about four months to about three years. The system consists of pumps which feed lubricant to two pendulum-mounted rail applicators mounted on the end carriages of the crane. Circular rollers forming the base of the penduli are pressed against the rail flanks by their own weight assisted by a tension spring. The lubricant passes through equidistant holes in the roller rims which are surfaced with stiff felt.

Another new system of crane wheel lubrication is a dry lubrication system, consisting of a special grade of graphite formed into a rod form and held in special holding devices fitted to the undercarriage of the crane. The rod is applied against the side of the rail. It is not necessary that this unit be applied to all cranes; one crane on a runway with a unit on each side may apply sufficient lubricant to handle a number of cranes.

A new motorized lifting device which will simplify sheet stacking is in operation at the Indiana Harbor Works of Inland Steel Co. With this device the crane operator raises and lowers the unit with the cab controls. The lifter is lowered over a pack with its arms opened wide enough for clearance. When it is positioned over the stack, the crane follower who controls the lateral movement of the arms operates a pushbutton control causing the arms to close on the pack and support it. When the load is delivered, the crane follower again operates the pushbutton control to open the arms and release the load. This aids stacking since it eliminates signaling by the follower to the crane operator.

An interesting development in grease handling, using bulk delivery, which promises very substantial savings, has been initiated by United States Steel at Gary in conjunction with a lubricant supplier. A unique tractor trailer truck delivers two grease containers to the industrial customer. The contents of the containers can be pumped into the customer's stationary storage tanks by a gear type pump which moves 100 gpm of grease. This replaces the conventional system in which grease is normally shipped in 400-lb drums which were stored until needed. The system eliminates the handling of these drums and also the need for the valuable storage space.

The grease flows from the central storage tanks to key points in the plant through centralized lubrication systems. The savings resulting from the new delivery system are substantial.

A further extension of this bulk handling may be to treat grease as a mill utility item. Basically this would consist of placing a header line reaching each and every department throughout a plant with the grease pumped from a central storage area. With an in-line pump it is believed feasible to pump distances up to 5000 ft if a booster pump is inserted about every 700 ft.

MECHANICAL

The first gas turbine in the steel industry for blast furnace blowing is now in operation at United States Steel Corp.'s South Works plant in Chicago. Advantages of the installation are that it requires less space than conventional steam turbine driven blower and boiler, and uses practically no water. This particular unit can supply 125,000 cfm of air to the furnaces, in addition to the air which is used in the combustion system of the turbine itself.

One of the largest turboblowers for blast furnaces is to be installed at United States Steel Corp.'s Edgar Thomson works. It will be rated at 165,000 cfm at 50-psi pressure, is an axial-flow design. The blower will be designed with split wind control to provide the total wind requirements of two of the blast furnaces at the Braddock plant. Completion is scheduled for the second quarter of 1961.

Advances in the art of producing power are still increasing conversion efficiency. In 1959 it took 0.89 lb of coal to produce 1 kwhr, compared with 1.19 lb in 1950. Generating units are becoming larger and there appears to be almost no limit to the size of the units

with the compound type multi-flow units which are being installed. Computer control is also being installed at the load dispatching centers of power utilities as well as in the engineering offices and generating plants. At one plant of Louisiana Power & Light Co., believed to be the first so-called fully automatic steam-electric plant, computers will start, stop and put back into operation the plant as required.

The trend to install the newer and larger plants at the source of fuel and where cooling water is available, rather than at the load center, means that larger blocks of power must be transmitted over long distances. This is leading to the introduction of extra high transmission-voltages in the 460 to 750-kv range.

It was estimated that the generating capacity of the U.S. electric power industry would reach 170,500,000 kw by the end of 1960 and go up to 203,000,000 kw by 1963. The nationwide output will reach 1,000,000,000,-000 kwhr by the end of 1963.

As of April, 1960, when a Commonwealth Edison Co.'s nuclear facility in northern Illinois went into operation, the United States had 350,000 kw of nuclear generating capacity. Another 670,000 kw of nuclear capacity is under construction.

In May one manufacturer received a letter of intent to negotiate contracts for the design and construction of a 360,000-kw atomic power plant for the Southern California Edison Co. This will have the world's largest atomic power reactor. Over-all plant cost is estimated at about $70,000,000.

Progress continues in atomic power plant design. It is reported that the electricity produced at the new Commonwealth Edison station previously mentioned will cost about the same as power generated from conventional fuels. This unit is a 180,000-kw plant, the world's largest operating nuclear power station, and also the first to be built through private financing. If the cost estimates prove out, it should signal commercial adoption of nuclear power on its own economics without subsidy.

First output from the plant was 65,000 kw when the plant was started in April. Production rate has been stepped up gradually, reaching capacity during the summer.

In December, an electrical manufacturer announced that, in cooperation with seven utilities, it will build an $8,000,000 superheat development reactor to extend technology of nuclear superheat for eventual application to large scale nuclear power plants. The new reactor to be built in California will be ready for operation in 1962. It will be rated at 15,000 thermal kw.

The oxygen industry is becoming a giant as steel plant usage increases. Estimates from a number of mills indicate that by far the largest proportion (about 25 per cent) of oxygen now being used is through roof jets into open hearths. About 15 per cent is going into open hearth combustion oxygen and from between five to ten per cent is being used in the blast furnace and in other oxygen vessels.

Some eighteen major oxygen plants are either under construction or projected in the near future with a total capacity of over 6000 tons of oxygen per day. In these proposals, the influence of new oxygen converter vessels on the demand is clearly shown.

These present programs should about double the capacity of oxygen available for steel mills to nearly 12,000 tons per day.

Another company entered the oxygen field in the United States this year. Its first unit to be installed at the Ford Motor Co.'s Steel Division is designed to produce simultaneously gaseous and liquid oxygen at low pressures. Scheduled to go into operation late in 1961, the plant will have a daily production rate of 280 tons of gaseous oxygen, 10 tons of liquid oxygen, 1.4 tons of liquid nitrogen all with 99.5 per cent purity. It will be one of the few oxygen plants owned by a steel plant.

Armco Steel Corp. authorized the construction of a unit which will supply 135 tons per day of oxygen to the Houston works of the Sheffield division. The plant will be located outside the steel plant area, and a pipe line will deliver the oxygen to the mill. Sheffield will use this oxygen in their open hearth and electric furnaces.

A natural gas cutting torch which can slice through as much as 30-in. of metal in a single pass has been developed. It has extremely large gas flow up to 3000 cfhr of oxygen and 250 cfhr of natural gas. By changing the injectors, it is possible to use it with either low or medium pressure natural gas.

Electron beam vacuum welding now being used has the advantage of eliminating atmospheric contamination which sometimes occurs in welds from the oxygen and nitrogen. Metal fusion is achieved from the kinetic energy of a controlled electron beam in a high vacuum. The parts are heated to the melting point by bombarding a localized area with high-energy electrons, accelerated by high voltage and focused into a beam which is directed at the work piece. It is claimed that the cost of welding is considerably less for electron beam vacuum welding than for inert gas, shielded tungsten welding. The weld is smooth, ductile and of good quality. The process is particularly advantageous in welding small thin components. First applications are on nuclear fuel elements.

Another welding technique is electroslag welding which was developed in the Soviet Union some ten years ago. The technique utilizes the electrical conductivity of a molten welding flux at high temperatures. A powerful electric arc is started and maintained under a layer of flux. When this layer is thick enough, an arcless phase begins, the current passes from the electrode to the workpiece through the conductive slag. The heat which is generated by the slag and in its molten slag-metal interface fuses the edges of the workpiece and the welding wire. Chief advantages are for joining thick-walled material such as high pressure boiler drums, large shafts, frames for rolling mills and other such components. It is claimed that the process can join metals up to 40-in. thick in one pass without edge beveling. The equipment can be designed for use with plate, single and three-wire electrodes. In the latter case, the deposition rate goes up to 135 lb per hr.

An electro-shaping process can produce very close tolerances in material regardless of the hardness. The process can form complete parts in addition to sinking cavities. Power is supplied by a simple rectifier. The workpiece is connected to the positive terminal of a d-c source. The electrodes are on the negative side and an electrolyte is between the workpiece and the elec-

trodes. These are all contained in a plastic chamber.

By varying current density, the location and amount of material to be removed is controlled. The speed of removal depends on the increase in direct current per unit of area, and the most material is removed at the spots which have the greatest current flow.

Some of the advantages are that the process has no tool wear, it uses standard semi-automatic feed devices, and the power source is simple. Since no pressures are involved, there is no deflection in the piece being machined, which is of advantage in very thin materials.

A new solid lubricant is claimed to have as much as 20 times normal load bearing capacity. This lubricant is compounded through the addition of various inorganic sulphides to molybdenum disulphide or tungsten disulphide.

Another synthetic solid lubricant for application in high-temperature jobs uses a synthetic carrying agent, a solid thickener and a fine particle graphite. After the carrier volatilizes, a soft film of graphite-based lubricant remains and there is no hard abrasive residue. It is claimed that the lubricant can be used at temperatures from below zero up to over 1000 F.

Increasing use is being made of various ultrasonic developments. Ultrasonic cleaning fits in very well with automatic procedures.

A number of steel mills are also considering the use of high speed scanning devices for spotting various types of defects. In general, they consist of a transducer which is coupled to the part being checked by a column of liquid, water or oil. These devices can be tied in with alarm devices which will mark the defects with paint sprays. They can also be used for keeping records through means of computer and data logging equipment. The major applications of such devices are to detect discontinuities such as voids, porosity, cracks, inclusions, seams, etc.

Ultrasonics are also being used in a number of welding and also in some machining processes.

An interesting application of soil mechanics was involved in the design of the new Midwest Steel plant. Here large savings were realized in the foundations by using spread footings. These savings were accomplished by obtaining data from a complete soil drilling and testing program, analyzing the results, and then taking advantage of the preloading of the site by prehistoric sand dunes. The procedure is particularly pertinent to sites along the Great Lakes.

A new explosion protection system will detect an explosion at the instant of its inception, and act within a few thousandths of a second to snuff out the blast before it can become destructive. It is claimed that the system is capable of dealing effectively with the vast majority of ordinary explosion hazards which exist throughout industry. The system is able to measure very rapid pressure build-ups. The blast is then made harmless by suppression, that is enveloping the explosion with a suppressant, by venting or by advance inerting or by isolation. A combination of methods may also be used.

A detector/relay combination based on infrared rays can sense the presence of moving hot objects and can start, stop or adjust relay-controlled equipment associated with a process. The unit can be used at distances up to 20 ft. Originally designed in conjunction with automatic rolling mill control systems for detecting position of hot strip, the feature which leads to adoption is that it responds only to *moving* hot objects and does not pick up a hot background. Possible uses in the plant are to close furnace doors, to start and stop water sprays, to control coilers, to reverse rolls and to count number and frequency of operations. The temperature of the object affects the speed at which it must move and the distance of the detector from the object. At a speed of 20 fpm and a distance of 5 ft, the temperature must be about 1300 F. However, as the moving object speed goes up to 1200 fpm, the temperature need be no higher than 600 F. If the distance is 20 ft and the speed is 20 fpm, the temperature must be 2050 F, but at speeds of 5000 fpm, temperature as low as 800 F will operate the equipment.

A unique electronic system can be used to inspect bearings without disassembling the bearing units. The system checks surface damage in rolling contact bearings, and is based on a sensitive vibration analysis which can discover flaws no deeper than 0.000001 in. The instrument can check a bearing very quickly and distinguish between damage of the rolling elements, and inner and outer races.

A new straight-line flow centrifugal fan was developed during the year which takes about half the space previously required. The unit combines the advantages of centrifugal fan performance with space-saving features of straight-line air flow. Efficiency of the unit is primarily due to the use of an air-foil type blade which reduces turbulence.

A major breakthrough in refractory metals technology is the production of a forgeable tungsten. This is obtained by combining electronbeam processing and critical composition control. The resultant cast tungsten and molybdenum ingots have increased ductility and workability without impairment of strength characteristics.

ELECTRICAL

In the electrical field, a most intensive effort is being made on application and development of computers and computer control to the various areas of the steel plant. With this is a trend to move heavily into areas where electrical control was formerly only a minor factor. The complexity of much of the equipment necessitates intensive training and new maintenance procedures by steel management.

It is now claimed that computer control has reached the stage where technical know-how in system, elements and equipment permit the tying together the islands of automation existing in many steel mills. This will result in a setup which will control everything from the customer's order to the delivery of the finished product. Such a system would include business and process information handling, process control and material handling—*the automatic steel plant.*

However, another viewpoint is that many engineers in their enthusiasm forget where the computer really fits in. Practically and economically, computers can be utilized only when the complex calculations and decisions required exceed both the operator's capabilities and his ability to react sufficiently fast. They should also be considered where complex calculations and decisions are required that exceed the operator's ca-

pability but where his reaction time is adequate if he has this information, or where a large number of simple comparisons and decisions are required and corrective action must be made quickly. Another case where the computer should be considered is where a large amount of operating data and summarizing information is required for operational reasons.

Before a computer control processing system can be properly engineered, several basic requirements must be satisfied:

1. Process equations that adequately describe the process must be available.
2. Control equipment must be available to perform the required control functions of the process.
3. Instrumentation must be available to measure the required system variables.

Nevertheless computers are starting to run equipment at an accelerating pace and giant steps are being taken by the machines in the job of production supervision.

In the steel industry one of the most advanced developments is the computer controlled hot strip mill being built for the Great Lakes Steel Corp. In this setup, temperatures at 113 points, four fuel-air ratios, 63 pressures at various locations (water, roll balance, stack), 40 position readings, 12 speed readings, four product dimension readings and one weight reading will be fed into the computer. The computer in turn will set speed control, screwdown settings, alarms and accounting data.

The AISE Iron and Steel Exposition this year showed a working model of one of the latest automated hot strip mill designs which foretells the steel mill of the future. In this mill the operator needs only to punch the measurements of the incoming slab and its temperature, set a vernier for the final gage and push a button. The computer takes over and establishes the optimum speed and roll openings of each stand. The control then starts the slabs after all the mill settings have been made. In the event a wrong setting is made, the mill will report back and punch a message on a typewriter to that effect to the operator. The computer normally distributes the load uniformly to all stands except the last, taking into account the drive motor capabilities. The load in the last stand is normally less than the other stands. Thickness gages continually measure the strip and in the event the final product does not meet final requirements, the control automatically makes adjustments to quickly give a suitable product.

Most attention has been centered on the hot strip mill, although other systems are installed on sintering, continuous annealing, tinplate lines and plant utilities. The reason for the application to the hot strip mill is that this is one of the largest single production units in the steel plant and one which involves tremendous capital investment. It is estimated also that automatic programming of such mills can be repaid in two years or less. This pay-off is primarily due to increase in yield and to uniform quality of the coils.

Maximum benefits from automatic control will come to new mills because such mills can be designed with drives of sufficiently large power capacity to withstand the fast continuous service. They will also have speed

Before extra high voltage lines are too widely adopted a number of problems must be solved. Corona discharge is one of these problems.

regulators with sufficiently fast response and accurate controls to minimize dead time, and they will have automatic gage control equipment.

The addition of digital control computers to old mills will also give benefits to the level permitted by the available equipment.

The trend in new computer control systems is to use transistorized static switching, digital and analog elements. These are combined in building-block fashion to produce a wide variety of reliable industrial control systems. In general, units are factory wired and installation is simplified through the use of plug-in elements and stab-on connectors.

It is understood that two computer controls are being considered for blast furnaces, one in the midwest and another on the new experimental blast furnace which United States Steel is to install at their Duquesne works. The latter installation will emphasize process analysis.

In the blast furnace the greater use of beneficiated ores, which better lend themselves to control of ore quality, may make it easier to predict blast furnace performance helping automatic control applications.

Automatic control of mixing and charging materials for the blast furnace is a feature at the Gary Works of the United States Steel Corp. In the system being installed, command information is set up by an operator with patchboard leads and selector switches. With this scheme, the operator can quickly set up or change the program, which includes sequence of skips, material included in each skip, the quantity of material in any one skip, and the bin in which the material is stored.

A new shipment of ore or flux can be stored in any one of the 14 bins.

In the system there are two main conveyors, each one serving seven hoppers. The material from each hopper is weighed on a weighing conveyor and deposited on a main conveyor. A weight sensing device on each weighing conveyor produces a digital pulse for every 50 lb of material. Because of the design of the digital counting system, two hoppers can unload the material onto a main conveyor at the same time, reducing over-all operating time. Once the operator has set the program on the patchboard, the charging cycle is completely automatic. If one bin of a given material is empty, the control will automatically choose another bin of the same material, as well as indicating the empty condition of the first bin. Also, if the chute of a bin becomes clogged, the control initiates a vibrator, and if this does not restore the material flow, the control will automatically sound an alarm and turn on indicating light.

There is automatic data accumulation on the control which records the weight of each material used, and the time at which it is charged into the furnace. This can be tied in with accounting purposes and also for comparing charging program with the quality of the finished product. Punched tape is used for the recording purposes.

A new x-ray emission gage enables analysis of a number of elements in materials during steady flow. The new gage can check the presence and amount of up to five elements with a reference. Radiation from the elements gives the amount of that element in the material being checked. The unit adapts itself to various forms such as liquids, slurries, solids, powders, sheets or rods. Output from the gage can be used for recording, for computing, for control. In steel, the most immediate application is in checking ore and sintering lines.

An interesting automatic control and computer application is now handling a sintering line in the mid-west. This gage will provide voltage outputs which are propotional to the per cent content of the chemical element being monitored. With this gage, plus an analog computer simulation of the process, a continuous regulating scheme has been successfully applied to automatically proportion the raw materials in the sinter mix and to control the sinter machine speed. This system has eliminated the need for ON–OFF interval timers to stabilize the drives which are characterized by relatively long transport time lags between the drive and the feed-back signal sensor.

A new low cost system features a data processing device that will answer the telephone and take messages in the form of punched cards. This transmission system consists of one or more sending stations linked to a central receiving station by dial telephone lines at regular toll rates or by leased telephone lines. This system has tremendous significance for centralized computer control.

Another development in communications for computer control enables two widely separated computers to exchange information directly over the telephone while each continues to print out the results of its calculations. The new equipment is designed to link the magnetic core memories of solid-state computers over regular local or long distance lines, and it enables two-way communication between computers at a rate of 150 characters per second.

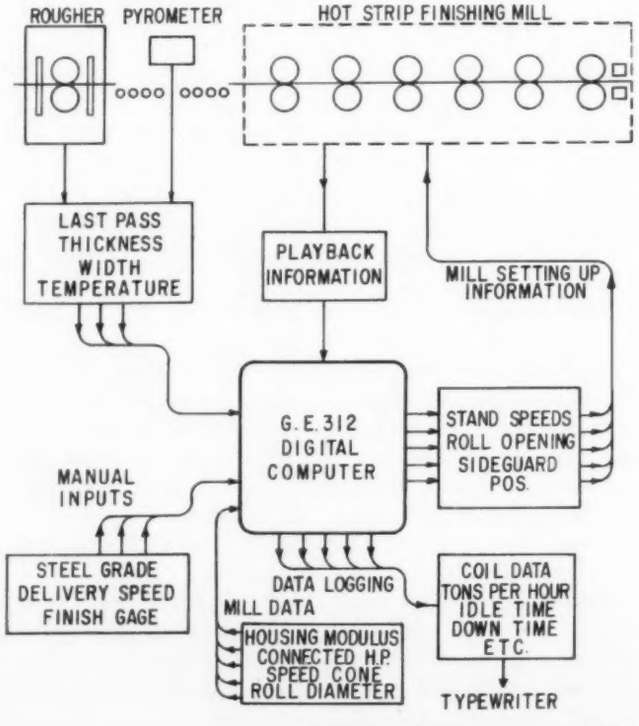
Another new development is an electronic machine which can read an employee's identification badge and tie him in with his work on the production line, for payroll and personnel purposes.

An interesting data accumulation system for process lines includes three identical computer sections which operate in parallel. On this system the answers from three computers are compared on a two-out-of-three basis. If there is any difference in the three answers, the majority rules and the correct answer is printed out. In the meantime the system indicates that a disagreement has occurred. The data are collected from a number of sensing devices mounted along the output section of the production line and from a manual station where visually detected defects are fed into the system. It is essential that all defects be correlated with the point on the strip at which they occur. This gathering of defect data into their appropriate points is accomplished within the unit. Binary-coded decimal notation is used in the computer sections.

The output section of each computer provides buffer storage for the accumulated totals to compensate for the speed of the output printer or typewriter. The single two-out-of-three voting section follows the buffer storage computer sections. It causes the correct answer to be fed from the appropriate buffer storage to the output device by way of a binary-coded decimal-to-decimal converter and a print-format programmer. The output device can be a printer, typewriter, tape punch, magnetic-tape recorder or other device.

Thus, in the tinplate line, the accumulator gives a measure of the footage of prime quality material, footage of reject material and the total number and locations of occurrences of each type of defect. In addition,

Schematic shows computer control on high speed finishing mill.



data such as the order number, crew, coil number and other fixed information are printed out to provide complete useful quality control records.

Each computer has only one high-speed arithmetic unit. The major portion of each computer services the channels in such a manner that one arithmetic system operates sequentially on all the channels.

Another advantage of the time-multiplexing is the utilization of the inherent high-speed capability of the delay lines without the requirement that the whole system use expensive high-speed units. One small section of high-speed computer elements separates, in a time-sharing manner, the pulses entering and leaving the magnetostrictive delay line. The output of this pulse-interleaving section is of low frequency, suitable for low-speed components.

In this particular data accumulation system, the three prime objectives in the design were: (1) to prevent errors from originating within the system; (2) to provide reliable uninterrupted operation; and (3) to reduce maintenance to the minimum. There are no vacuum tubes in this system and no moving parts in the computer.

The remarkable growth of semi-conductor devices continues. In just a few years the static converter has grown from a level of watts to one of kilowatts. Larger power ratings are aimed at in present research and development programs, and the laboratories say that in the next few years, semiconductor inverters will be in the 10,000 to 100,000-kw area.

One of the largest silicon rectifier units was put into operation by Alcoa at one of its smelters. This unit is rated 10,000 amperes, and can deliver 6000 kw power from only 312 silicon cells.

A new transistor has been developed which is capable of operating at about 650 F. This transistor is made from silicon carbide. The unit is still in the laboratory stages of development, but promises a much wider range of operation than presently available from present transistors of germanium and silicon which can operate at temperatures no higher than about 200 F.

A new infrared system which is sensitive enough to see moving objects near room temperature solely by means of the invisible heat rays has been developed. This is a phothermionic image converter. It will change infrared radiation emitted by an object into a visible picture on a television screen. The system is sensitive enough to detect moving objects near room temperature when they exhibit temperature differences of approximately 20 F, which is about the spread between the temperature of the human body and that of the average living room. In addition, the system is fast enough to follow the movement of such objects with the same speed as a normally visible object is followed by the unaided human eye.

An electronic tube which is capable of detecting fire by sensing its ultraviolet radiation is a recent development. This tube, which is smaller than a golf ball, is insensitive to direct sunlight, normal illumination enclosed in glass, cosmic or nuclear radiation. The unit was designed to be used as a fire detector to provide a nearly instantaneous alarm, or in flame-out applications for the detection of absence of flames in boiler fire boxes, furnaces and other combustion chambers. As a fire detector it has advantages over such things as sprinkler systems or thermostats under which the fire has to be partially under way before they can activate the sprinkler valves. The unit is operated with an ambient temperature range of 75 to 400 F.

There has been much interest during the year on the use of a fuel cell to produce power. In contrast to conventional batteries, a fuel cell uses a low cost fuel and an oxidant which is continuously fed into the system. Several types are in use but they all exhibit basic similarities. One of the simplest is an oxygen concentration cell consisting of an electrolyte that conducts an electric charge in the form of oxygen ions but is an insulator to electrons. The electrolyte is sandwiched between two electrodes. A voltage is created between the electrodes when the oxygen is at different concentrations at the two electrode-electrolyte interfaces.

Some of the advantages of the fuel cells are that they contain no moving parts and can operate silently. Efficiency is independent of the cell size over a wide range of power output. The fuel cells are low voltage, d-c devices. The most interesting property is that they do not operate on a heat cycle, the limiting factor in the efficiency of steam turbine generators and heat engines. Theoretically, fuel cells should be able to produce twice as much useful energy from fossil fuels as today's most efficient steam turbine generator unit. This would be as high as 70 to 90 per cent compared with the maximum 42 per cent for the most modern central station plant.

Power generated by magnetohydrodynamic generators may be a future development in power generation. The word "magnetohydrodynamic" (MHD) stands for the use of a fluid conductant to produce an electric current instead of the rotating solid copper bars going by energized field windings as in the conventional generator. Instead of a fluid, the practical realization of such a power generator at the present time appears to depend on the use of a conducting gas, which may be obtained by partially ionizing the gas by heating it sufficiently to make it conductive.

In general, however, the problem has been that the temperature required for sufficient gas ionization is beyond the limits of most known materials. However, when the gas is seeded with an alkali metal such as potassium, or cesium, electrical conductivity can be realized at lower temperatures down to 4000 F. Such generators may have efficiencies as high as 80 to 90 per cent when operated somewhat below their maximum power capabilities. The over-all thermal efficiency of a plant using an MHD generator might be as high as 60 per cent compared with 40 to 42 per cent for the most modern conventional plants.

A thermoelectric generator system will be used by the Coast Guard for a navigation light. The unit for the Coast Guard will have an average power output of five watts.

Another application being developed will use thermoelectricity in refrigerators. The thermoelectric generator uses propane gas which is burned to provide heat which passes between two dissimilar conductive materials which are joined at both ends, producing a current. Thermoelectric generators are rugged, compact and free of moving parts and thus are extremely reliable. They should probably be lower in capital cost than

(*Please turn to page 178*)

ELECTRIC MOTOR DRIVES THREE HUNDRED HORSEPOWER AND OVER

APPLIED TO ROLLING MILLS IN THE IRON AND STEEL AND ALLIED INDUSTRIES DURING 1960

Item	Horse-power	Revolutions per minute	Volts	Fre-quency	Method of drive	Type of mill	Purchaser	Location	Manufacturer
1①	250	850/1100	250	d-c	Direct	57-In., 2-stand skin pass mill-entry tension device	Societe Lorraine de Laminage Continu (Sollac)	Paris, France	Westinghouse
2①	250	850/1100	250	d-c	Direct	57-In., single stand skin pass mill-delivery tension device	Societe Lorraine de Laminage Continu (Sollac)	Paris, France	Westinghouse
3	250	100/300	750	d-c	Geared	Combination rod and merchant mill stand 1	Union Siderurgica Asturianas, S.A.	Madrid, Spain	Westinghouse
4	300	500/1000	315	d-c	Direct	60-In., 4-high aluminum reversing cold mill, winding reel	Aluminium Co. of Canada Ltd. for Indian aluminum	Calcutta, India	General Electric
5	333	400/1230	300	d-c	Geared	80-In., 2-high skin pass mill payoff reel	National Steel Corp.; Great Lakes Steel Corp. Div.	Ecorse, Mich.	Westinghouse
6	333	400/1230	300	d-c	Geared	80-In., 2-high skin pass mill payoff reel	National Steel Corp., Great Lakes Steel Corp. Div.	Ecorse, Mich.	Westinghouse
7	350	400/800	600	d-c	Geared	Rail rerolling mill intermediate stand	Inland Steel Co.	Chicago Heights, Ill.	Allis-Chalmers
8	350	400/800	600	d-c	Geared	Rail rerolling mill intermediate stand	Inland Steel Co.	Chicago Heights, Ill.	Allis-Chalmers
9†	350	720	550	60	Geared	Copper rod mill roughing stand	Narragansett Wire & Cable Co.	Pawtucket, R. I.	Elliott
10	350	225/1040	600	d-c	Geared	42-In., 2-stand temper mill delivery tension reel	Breedband, N.V.	Netherlands	General Electric
11	350	300/1390	375	d-c	Direct	57-In., 2-stand skin pass mill payoff reel	Societe Lorraine de Laminage Continu (Sollac)	Paris, France	Westinghouse
12	350	300/1390	375	d-c	Direct	57-In., 2-stand skin pass mill payoff reel	Societe Lorraine de Laminage Continu (Sollac)	Paris, France	Westinghouse
13	350	240/800	375	d-c	Direct	57-In., single stand skin pass mill payoff reel	Societe Lorraine de Laminage Continu (Sollac)	Paris, France	Westinghouse
14	350	240/800	375	d-c	Direct	57-In., single stand skin pass mill payoff reel	Societe Lorraine de Laminage Continu (Sollac)	Paris, France	Westinghouse
15	400	225/900	600	d-c	Geared	66-In., temper mill delivery reel	Republic Steel Corp.	Massillon, Ohio	Allis-Chalmers
16	400	175/650	350	d-c	Direct	80-In., sheet temper mill entry reel	National Steel Corp., Midwest Steel Corp. Div.	Portage, Ind.	Allis-Chalmers
17	400	175/650	350	d-c	Direct	80-In., sheet temper mill entry reel	National Steel Corp., Midwest Steel Corp. Div.	Portage, Ind.	Allis-Chalmers
18①	400	300/1200	230	d-c	Geared	Temper mill uncoiler	Republic Steel Corp.	Warren, Ohio	Elliott
19②	400	690/1000	600	d-c	Direct	42-In., 2-stand temper mill entry tension reel	Breedband, N.V.	Netherlands	General Electric
20	400	200/700	250	d-c	Geared	4-High aluminum non-reversing cold strip mill payoff reel	Bridgeport Brass Co.	Warren, Ohio	General Electric
21②	400	400/1350	460	d-c	Geared	44-In., aluminum non-reversing cold strip mill	Scovill Mfg. Co.	Waterbury, Conn.	General Electric
22	400	575/1150	250	d-c	Geared	Reversing cold strip mill	Thompson Wire Co.	Boston, Mass.	General Electric
23④⑥	400	690/875	250	d-c	Geared	66-In., pickle line temper mill	United States Steel Corp., Gary Sheet & Tin Div.	Gary, Ind.	Reliance Electric & Engineering Co.
24	400	175/610	750	d-c	Direct	80-In., temper mill payoff reel	Cosider, S.P.A. Mura Di Santa Chiarai	Genoa, Italy	Westinghouse
25	400	175/610	750	d-c	Direct	80-In., temper mill payoff reel	Cosider, S.P.A. Mura Di Santa Chiarai	Genoa, Italy	Westinghouse
26†	450	720	550	60	Geared	Copper rod mill roughing stand	Narragansett Wire & Cable Co.	Pawtucket, R. I.	Elliott
27①	500	300/1050	550	d-c	Geared	77-In., aluminum cold mill reel	Fairmont Aluminum Co.	Fairmont, W. Va.	Elliott
28①	500	300/1050	550	d-c	Geared	77-In , aluminum cold mill reel	Fairmont Aluminum Co.	Fairmont, W. Va.	Elliott
29	500	400/1200	600	d-c	Geared	4-High aluminum cold roughing and finishing mill	Aluminium Co. of Canada, Ltd.	Alcan de Columbia	General Electric
30	500	400/1385	500	d-c	Geared	4-High aluminum non-reversing cold mill winding reel	Quaker State Metals Co.	Lancaster, Pa.	General Electric
31②	500	250/1000	600	d-c	Geared	19-In., sendzimir mill reel	Thompson Wire Co.	Franklin Park, Ill.	General Electric
32②	500	250/1000	600	d-c	Geared	19-In., sendzimir mill reel	Thompson Wire Co.	Franklin Park, Ill.	General Electric
33①	500	850/1100	500	d-c	Direct	57-In., 2-stand skin pass mill entry tension device	Societe Lorraine de Laminage Continu (Sollac)	Paris, France	Westinghouse
34①②	500	850/1100	500	d-c	Direct	57-In., 2-stand skin pass mill, delivery tension device	Societe Lorraine de Laminage Continu (Sollac)	Paris, France	Westinghouse
35①③	500	850/1100	500	d-c	Direct	57-In., single stand skin pass mill, delivery tension device	Societe Lorraine de Laminage Continu (Sollac)	Paris, France	Westinghouse
36	500	300/900	750	d-c	Geared	Combination rod and merchant mill, stand 2 and 3	Union Siderurgica Asturianas, S. A.	Madrid, Spain	Westinghouse
37	500	300/900	750	d-c	Geared	Combination rod and merchant mill, stand 4 and 5	Union Siderurgica Asturianas, S. A.	Madrid, Spain	Westinghouse
38①	500	250/750	600	d-c	Geared	30-In., reversing cold mill	Universal Cyclops Steel Corp.	Coshocton, Ohio	Westinghouse
39①	500	250/750	600	d-c	Geared	30-In., reversing cold mill	Universal Cyclops Steel Corp.	Coshocton, Ohio	Westinghouse
40	600	250/700	600	d-c	Geared	Merchant rod and skelp mill revamp, stand 11	Acindar	Argentina	General Electric
41	600	250/830	600	d-c	Geared	Merchant, rod and skelp mill revamp, stand 12	Acindar	Argentina	General Electric
42	600	175/525	600	d-c	Geared	Bar mill cross country train stand 2	Border Steel Rolling Mill, Inc.	El Paso, Texas	General Electric
43	600	400/1200	500	d-c	Geared	4-High aluminum non-reversing cold strip mill	Bridgeport Brass Co.	Riverside, Calif.	General Electric
44③	600	200/700	250	d-c	Geared	4-High aluminum non-reversing cold strip mill, winding reel	Bridgeport Brass Co.	Warren, Ohio	General Electric
45③	600	400/1350	690	d-c	Geared	44-In., aluminum non-reversing cold strip mill reel	Scovill Mfg. Co.	Waterbury, Conn.	General Electric
46	600	400/800	600	d-c	Geared	19-In., sendzimir mill	Thompson Wire Co.	Franklin Park, Ill.	General Electric
47	600	600/1200	600	d-c	Direct	62-In., foil mill	Aluminium Co. of Canada, Ltd.	Kingston, Ont.	Westinghouse (Can)
48	600	690/1330	600	d-c	Geared	48-In., 4-high reversing cold mill	Manufacturas de Cobre (Madeco)	Santiago, Chile	Westinghouse
49③	600	300/980	250	d-c	Geared	30-In., reversing cold mill left tension reel	Universal Cyclops Steel Corp.	Coshocton, Ohio	Westinghouse
50③	600	300/980	250	d-c	Geared	30-In., reversing cold mill right tension reel	Universal Cyclops Steel Corp.	Coshocton, Ohio	Westinghouse
51①	700	400/600	750	d-c	Direct	57-In. skin pass mill stand 1	Societe Lorraine de Laminage Continu (Sollac)	Paris, France	Westinghouse
52①	700	400/600	750	d-c	Direct	57-In. skin pass mill stand 1	Societe Lorraine de Laminage Continu (Sollac)	Paris, France	Westinghouse
53①	700	400/600	750	d-c	Direct	57-In. skin pass mill stand 2	Societe Lorraine de Laminage Continu (Sollac)	Paris, France	Westinghouse
54①	700	400/600	750	d-c	Direct	57-In. skin pass mill stand 2	Societe Lorraine de Laminage Continu (Sollac)	Paris, France	Westinghouse
55③	700	300/1390	375	d-c	Direct	57-In. 2-stand skin pass mill tension reel	Societe Lorraine de Laminage Continu (Sollac)	Paris, France	Westinghouse
56①	700	400/800	750	d-c	Direct	57-In. single stand skin pass mill	Societe Lorraine de Laminage Continu (Sollac)	Paris, France	Westinghouse
57①	700	400/800	750	d-c	Direct	57-In., single stand skin pass mill	Societe Lorraine de Laminage Continu (Sollac)	Paris, France	Westinghouse
58	700	300/900	750	d-c	Geared	Combination rod and merchant mill stand 6 and 7	Union Siderurgica Asturianas, S. A.	Madrid, Spain	Westinghouse
59	700	300/900	750	d-c	Geared	Combination rod and merchant mill, stand 8 and 9	Union Siderurgica Asturianas, S. A.	Madrid, Spain	Westinghouse
60①	750	250/720	600	d-c	Direct	80-In., sheet temper mill	National Steel Corp., Midwest Steel Corp. Div.	Portage, Ind.	Allis-Chalmers
61①	750	250/720	600	d-c	Direct	80-In. sheet temper mill	National Steel Corp., Midwest Steel Corp. Div.	Portage, Ind.	Allis-Chalmers
62①	750	90/270	700	d-c	Geared	110-In., reversing plate mill vertical edger	Alan Wood Steel Co.	Conshohocken, Pa.	Westinghouse
63①	750	90/270	700	d-c	Geared	110-In., reversing plate mill vertical edger	Alan Wood Steel Co.	Conshohocken, Pa.	Westinghouse
64①③	750	850/1100	750	d-c	Direct	57-In. 2-stand skin pass mill delivery tension device	Societe Lorraine de Laminage Continu (Sollac)	Paris, France	Westinghouse
65③	800	175/600	300	d-c	Direct	80-In. sheet temper mill delivery reel	National Steel Corp., Midwest Steel Corp. Div.	Portage, Ind.	Allis-Chalmers

Item	Horse-power	Revolutions per minute	Volts	Frequency	Method of drive	Type of mill	Purchaser	Location	Manufacturer
66③	800	175/600	300	d-c	Direct	80-In. sheet temper mill delivery ree	National Steel Corp., Midwest Steel Corp. Div.	Portage, Ind.	Allis-Chalmers
67	800	150/450	500	d-c	Geared	Bar mill cross country train-stand 1	Border Steel Rolling Mill, Inc.	El Paso, Texas	General Electric
68†	800	1500	2,300	50	Geared	5-Stand rod mill	Herramientas	Mexico	General Electric
69①	800	500/1030	600	d-c	Geared	80-In., 2-high skin pass mill	National Steel Corp., Great Lakes Steel Corp. Div.	Ecorse, Mich.	Westinghouse
70①	800	500/1030	600	d-c	Geared	80-In., 2-high skin pass mill	National Steel Corp., Great Lakes Steel Corp. Div.	Ecorse, Mich.	Westinghouse
71	800	300/900	750	d-c	Geared	Combination rod and merchant mill, stand 10 and 11	Union Siderurgica Asturianas, S. A.	Madrid, Spain	Westinghouse
72	900	575/1070	600	d-c	Direct	42-In., 2-stand temper mill, stand 1	Breedband, N. V.	Netherlands	General Electric
73	1,000	400/1000	700	d-c	Direct	60-In., 4-high aluminum reversing cold mill	Aluminium Co. of Canada, Ltd. for Indian Aluminum	Calcutta, India	General Electric
74†	1,000	720	4,000	60	Geared	Bar mill rougher	Border Steel Rolling Mill, Inc.	El Paso, Texas	General Electric
75	1,000	400/900	600	d-c	Geared	64-In., 2-high aluminum non-reversing cold finishing mill	Consolidated Aluminum Corp.	Jackson, Tenn.	General Electric
76	1,000	300/750	700	d-c	Geared	4-High aluminum non-reversing cold mill	Quaker State Metals Co.	Lancaster, Pa.	General Electric
77	1,000	300/900	750	d-c	Geared	Combination rod and merchant mill, stand 12 and 13	Union Siderurgica Asturianas, S. A.	Madrid, Spain	Westinghouse
78	1,000	300/900	750	d-c	Geared	Combination rod and merchant mill, stand 14 and 15	Union Siderurgica Asturianas, S. A.	Madrid, Spain	Westinghouse
79③	1,000	150/625	600	d-c	Direct	Temper mill tension reel	Republic Steel Corp.	Warren, Ohio	Elliott
80③	1,200	350/850	600	d-c	Direct	42-In., 2-stand temper mill, stand 2	Breedband, N. V.	Netherlands	General Electric
81*	1,200	150	6,600	60	Geared	110-In., reversing plate mill scalebreaker	Alan Wood Steel Co.	Conshohocken, Pa.	Westinghouse
82③	1,200	450/1280	600	d-c	Geared	80-In., 2-high skin pass mill tension reel	National Steel Corp., Great Lakes Steel Corp. Div.	Ecorse, Mich.	Westinghouse
83	1,500	150/525	700	d-c	Geared	44-In., aluminum non-reversing cold strip mill	Scovill Mfg Co.	Waterbury, Conn	General Electric
84③	1,500	300/1390	700	d-c	Geared	57-In., tandem cold strip mill, tension reel	Societe Lorraine de Laminage Continu (Sollac)	Paris, France	General Electric
85	1,500	450/900	600	d-c	Geared	10-In. merchant mill, stand 1	Steel Company of Canada, Ltd.	Hamilton, Ontario, Canada	Westinghouse (Can)
86	1,500	225/450	600	d-c	Geared	20-In., 5-stand hot strip mill stand 4	Copperweld Steel Co., Superior Steel Div.	Carnegie, Pa.	Westinghouse
87	1,500	250/660	750	d-c	Direct	80-In. temper mill	Cosider, S.P.A. Mura Di Santa Chiarai	Genoa, Italy	Westinghouse
88③	1,500	240/800	750	d-c	Direct	57-In., single stand skin pass mill tension reel	Societe Lorraine de Laminage Continu (Sollac)	Paris, France	Westinghouse
89③	1,600	175/610	750	d-c	Direct	80-In., tandem cold mill tension reel	Cosider, S.P.A. Mura Di Santa Chiarai	Genoa, Italy	Westinghouse
90③	1,600	175/610	750	d-c	Direct	80-In., temper mill tension reel	Cosider, S.P.A. Mura Di Santa Chiarai	Genoa, Italy	Westinghouse
91	1,750	650/850	600	d-c	Geared	Merchant, rod and skelp mill revamp, stands 13-18	Acindar	Argentina	General Electric
92①	1,750	250/575	700	d-c	Geared	57-In. tandem cold strip mill stand 1	Societe Lorraine de Laminage Continu (Sollac)	Paris, France	General Electric
93①	1,750	250/575	700	d-c	Geared	57-In., tandem cold strip mill stand 1	Societe Lorraine de Laminage Continu (Sollac)	Paris, France	General Electric
94③	2,000	200/600	700	d-c	Geared	4-High aluminum nonreversing cold strip mill	Bridgeport Brass Co.	Warren, Ohio	General Electric
95	2,000	80/280	700	d-c	Direct	52-In., tandem cold strip mill stand 1	United States Steel Corp., Tennessee Coal & Iron Div.	Fairfield, Ala.	General Electric
96①	2,000	225/563	700	d-c	Geared	52-In., tandem cold strip mill stand 2	United States Steel Corp., Tennessee Coal & Iron Div.	Fairfield, Ala.	General Electric
97①	2,000	225/563	700	d-c	Geared	52-In., tandem cold strip mill stand 2	United States Steel Corp., Tennessee Coal & Iron Div.	Fairfield, Ala.	General Electric
98①	2,000	150/450	750	d-c	Geared	80-In., tandem cold mill stand 1	Cosider, S.P.A. Mura Di Santa Chiarai	Genoa, Italy	Westinghouse
99①	2,000	150/450	750	d-c	Geared	80-in., tandem cold mill stand 1	Cosider, S.P.A. Mura Di Santa Chiarai	Genoa, Italy	Westinghouse
100③	2,100	300/1500	700	d-c	Geared	52-In., tandem cold strip mill tension reel	United States Steel Corp., Tennessee Coal & Iron Div.	Fairfield, Ala.	General Electric
101①	2,250	250/555	700	d-c	Geared	57-In., tandem cold strip mill stand 2	Societe Lorraine de Laminage Continu (Sollac)	Paris, France	General Electric
102①	2,250	250/555	700	d-c	Geared	57-In., tandem cold strip mill stand 2	Societe Lorraine de Laminage Continu (Sollac)	Paris, France	General Electric
103①	2,500	250/490	700	d-c	Geared	57-In., tandem cold strip mill stand 3	Societe Lorraine de Laminage Continu (Sollac)	Paris, France	General Electric
104①	2,500	250/490	700	d-c	Geared	57-In., tandem cold strip mill stand 3	Societe Lorraine de Laminage Continu (Sollac)	Paris, France	General Electric
105①	2,500	250/490	700	d-c	Geared	57-In., tandem cold strip mill stand 4	Societe Lorraine de Laminage Continu (Sollac)	Paris, France	General Electric
106①	2,500	250/490	700	d-c	Geared	57-In., tandem cold strip mill stand 4	Societe Lorraine de Laminage Continu (Sollac)	Paris, France	General Electric
107①	2,500	225/530	700	d-c	Geared	52-In., tandem cold strip mill stand 3	United States Steel Corp., Tennessee Coal & Iron Div.	Fairfield, Ala.	General Electric
108①	2,500	225/530	700	d-c	Geared	52-In., tandem cold strip mill stand 3	United States Steel Corp., Tennessee Coal & Iron Div.	Fairfield, Ala.	General Electric
109①	3,000	40/80	700	d-c	Direct	96-In. blooming mill	Alan Wood Steel Co.	Conshohocken, Pa.	General Electric
110①	3,000	40/80	700	d-c	Direct	96-In. blooming mill	Alan Wood Steel Co.	Conshohocken, Pa.	General Electric
111	3,000	200/450	700	d-c	Direct	60-In., 2-stand aluminum cold mill stand 1	Aluminum Co. of America	Davenport, Iowa	General Electric
112	3,000	225/500	700	d-c	Direct	60-In., 2-stand aluminum cold mill stand 2	Aluminum Co. of America	Davenport, Iowa	General Electric
113①②	3,000	400/800	700	d-c	Geared	57-In., tandem cold strip mill stand 5	Societe Lorraine de Laminage Continu (Sollac)	Paris, France	General Electric
114①②	3,000	400/800	700	d-c	Geared	57-In., tandem cold strip mill stand 5	Societe Lorraine de Laminage Continu (Sollac)	Paris, France	General Electric
115①②	3,000	350/700	700	d-c	Geared	52-In., tandem cold strip mill stand 4	United States Steel Corp., Tennessee Coal & Iron Div.	Fairfield, Ala.	General Electric
116①②	3,000	350/700	700	d-c	Geared	52-In., tandem cold strip mill stand 4	United States Steel Corp., Tennessee Coal & Iron Div.	Fairfield, Ala.	General Electric
117①②	3,000	350/700	700	d-c	Geared	52-In., tandem cold strip mill stand 5	United States Steel Corp., Tennessee Coal & Iron Div.	Fairfield, Ala.	General Electric
118①②	3,000	350/700	700	d-c	Geared	52-In., tandem cold strip mill stand 5	United States Steel Corp., Tennessee Coal & Iron Div.	Fairfield, Ala.	General Electric
119*	3,000	225	13,200	60	Geared	160/210-In., reversing plate mill scale-breaker	United States Steel Corp., Gary Steel Works	Gary, Ind.	Westinghouse
120	3,000	100/200	600	d-c	Direct	54-In., hot strip mill stand F-4	Empire-Reeves Steel Corp., Subsidiary of Universal Cyclops Steel Corp	Mansfield, Ohio	Westinghouse
121	3,000	150/300	600	d-c	Direct	54-In., hot strip mill stand F-6	Empire-Reeves Steel Corp., Subsidiary of Universal Cyclops Steel Corp.	Mansfield, Ohio	Westinghouse
122	3,500	225/445	600	d-c	Direct	54-In., tandem cold strip mill stand 4	Republic Steel Corp.	Gadsden, Ala.	General Electric
123	3,500	135/305	600	d-c	Direct	42-In., tandem cold strip mill stand 4	Republic Steel Corp	Warren, Ohio	General Electric
124①②	3,500	350/700	700	d-c	Geared	52-In., tandem cold strip mill stand 6	United States Steel Corp., Tennessee Coal & Iron Div.	Fairfield, Ala.	General Electric
125①②	3,500	350/700	700	d-c	Geared	52-In., tandem cold strip mill stand 6	United States Steel Corp., Tennessee Coal & Iron Div.	Fairfield, Ala.	General Electric
126①②	3,500	225/540	750	d-c	Geared	80-In., tandem cold mill stand 2	Cosider, S.P.A. Mura Di Santa Chiarai	Genoa, Italy	Westinghouse
127①②	3,500	225/540	750	d-c	Geared	80-In., tandem cold mill stand 2	Cosider, S.P.A. Mura Di Santa Chiarai	Genoa, Italy	Westinghouse
128①②	3,500	225/540	750	d-c	Geared	80-In., tandem cold mill stand 3	Cosider, S.P.A. Mura Di Santa Chiarai	Genoa, Italy	Westinghouse
129①②	3,500	225/540	750	d-c	Geared	80-In., tandem cold mill stand 3	Cosider, S.P.A. Mura Di Santa Chiarai	Genoa, Italy	Westinghouse
130①②	3,500	225/540	750	d-c	Geared	80-In., tandem cold mill stand 4	Cosider, S.P.A. Mura Di Santa Chiarai	Genoa, Italy	Westinghouse
131①②	3,500	225/540	750	d-c	Geared	80-In., tandem cold mill stand 4	Cosider, S.P.A. Mura Di Santa Chiarai	Genoa, Italy	Westinghouse
132①	4,000	40/80	700	d-c	Direct	110-In., reversing plate mill	Alan Wood Steel Co.	Conshohocken, Pa.	Westinghouse
133①	4,000	40/80	700	d-c	Direct	110-In., reversing plate mill	Alan Wood Steel Co.	Conshohocken, Pa.	Westinghouse
134	5,000	35/70	700	d-c	Direct	130-In., 4-high reversing plate mill	Altos Hornos de Mexico, S. A.	Monclova, Coahuila, Mexico	General Electric
135*	5,000	240	6,600	60	Geared	110-In., non-reversing plate finishing mill	Alan Wood Steel Co.	Conshohocken, Pa.	Westinghouse
136	5,000	100/200	700	d-c	Direct	48/84-In., 4-high reversing hot strip mill	Altos Hornos de Mexico, S. A.	Montclova, Coahuila, Mexico	Westinghouse
137	6,000	125/250	600	d-c	Geared	79-In., hot strip mill stand 10	Bethlehem Steel Corp.	Lackawanna, N. Y.	General Electric
138①	6,000	40/80	800	d-c	Direct	160/210-In., reversing plate mill	United States Steel Corp., Gary Steel Works	Gary, Ind.	Westinghouse

ELECTRIC MOTOR DRIVES THREE HUNDRED HORSEPOWER AND OVER

(Continued)

Item	Horse-power	Revolutions per minute	Volts	Frequency	Method of drive	Type of mill	Purchaser	Location	Manufacturer
139①	6,000	40/80	800	d-c	Direct	160/210-In. reversing plate mill	United States Steel Corp., Gary Steel Works	Gary, Ind.	Westinghouse
140②	8,000	175/450	700	d-c	Geared	80-In., hot strip mill stand F-2	Union Siderurgica Du Nord de la France (Usinor)	Paris, France	Westinghouse

* Indicates synchronous motor. † Indicates induction motor.
① Indicates twin motor drive. ② Indicates double armature. ③ Indicates triple armature. ④ One-half double armature. ⑤ AISE mill motor frame when used. ⑥ Present motor used for one-half twin drive.

MOTOR RECAPITULATION

Company	Location	Type of mill	Number of motors	Total horsepower
Acindar	Argentina	Merchant rod and skelp mill revamp	3	2,950
Alan Wood Steel Co.	Conshohocken, Pa.	96-In. blooming mill	2	6,000
		110-In. reversing plate mill	5	10,700
		110-In. non-reversing plate mill	1	5,000
Altos Hornos de Mexico	Montclova, Coahuila, Mexico	130-In., 4-high reversing plate mill	1	5,000
		48/84-In., 4-high hot strip mill	1	5,000
Aluminum Company of America	Davenport, Iowa	60-In., 2-stand aluminum cold strip mill	2	6,000
Aluminium Company of Canada, Ltd.	Kingston, Ont.	62-In. foil mill	1	600
Aluminium Company of Canada, Ltd.	Alcan de Columbia	4-High aluminum cold roughing and finishing mill	1	500
Aluminium Company of Canada, Ltd., for Indian Aluminium	Calcutta, India	60-In., 4-high aluminum reversing cold mill	2	1,300
Bethlehem Steel Co.	Lackawanna, N. Y.	79-In. hot strip mill	1	6,000
Border Steel Rolling Mill, Inc.	El Paso, Texas	Bar mill	3	2,400
Breedband, N. V.	Netherlands	42-In., 2-stand temper mill	4	2,850
Bridgeport Brass Co.	Riverside, Calif	4-High aluminum non-reversing cold strip mill	1	600
	Warren, Ohio	4-High alumirum non-reversing cold strip mill	3	3,000
Consolidated Aluminum Corp.	Jackson, Tenn.	64-In., 2-high aluminum non reversing cold finishing mill	1	1,000
Cosider, S.P.A. Mura Di Santa Chiarai	Genoa, Italy	80-In., 4-stand tandem cold mill	9	26,600
		80-In temper mill	4	3,9 0
Copperweld Steel Co., Superior Steel Div	Carnegie, Pa.	20-In., 5-stand hot strip mill, stand 4	1	1,500
Fairmont Aluminum Co.	Fairmont, W Va.	77-In. aluminum cold mill reel	2	1,000
Herramientas	Mexico	5-Stand rod mill	1	800
Inland Steel Co.	Chicago Heights, Ill.	Rail rerolling mill, intermediate stand	2	700
Manufacturas de Cobre (Madeco)	Santiago, Chile	48-In., 4-high reversing cold mill	1	600
Narragansett Wire & Cable Co	Pawtucket, R. I.	Copper rod mill roughing stands	2	800
National Steel Corp.				
Great Lakes Steel Div.	Ecorse, Mich.	80-In., 2-high skin pass mill	5	3,486
Midwest Steel Div.	Portage, Ind.	80-In. sheet temper mill	6	3,900
Quaker State Metals Co.	Lancaster, Pa.	4-High aluminum non-reversing cold strip mill	2	1,500
Republic Steel Corp.	Gadsden, Ala.	54-In. tandem cold strip mill, stand 4 addition	1	3,500
	Warren, Ohio	42-In. tandem cold strip mill, stand 4 addition	1	3,500
		Temper mill	2	1,400
	Massillon, Ohio	68-In. temper mill	1	400
Scovill Manufacturing Co.	Waterbury, Conn.	44-In. aluminum non reversing cold strip mill	3	2,500
Societe Lorraine de Laminage Continu (Sollac)	Paris, France	57-In. tandem cold strip mill	11	25,500
		57-In., 2-stand skin pass mill	11	6,200
		57-In., single stand skin pass mill	7	4,350
Steel Co. of Canada, Ltd.	Hamilton, Ontario	10-In. merchant mill, stand 1	1	1,500
Thompson Wire Co.	Boston, Mass.	Reversing cold strip mill	1	400
	Franklin Park, Ill.	19-In. sendzimir mill	3	1,600
Union Siderurgica Asturianas, S. A.	Madrid, Spain	Combination 15-stand rod and merchant mill	8	5 450
Union Siderurgica Du Nord de la France (Usinor)	Paris, France	80-In. hot strip mill, stand F-2	1	8,000
United States Steel Corp.				
Gary Steel Works	Gary, Ind.	160/210-In. reversing plate mill	3	15,000
Gary Sheet and Tin Div.	Gary, Ind.	66-In. pickle line temper mill	1	400
Tennessee Coal & Iron Div.	Fairfield, Ala.	52-In., 6-stand tandem cold strip mill	12	32,100
Universal Cyclops Steel Corp., Empire Reeves Div.	Coshocton, Ohio	30-In. reversing cold mill	4	2,200
	Mansfield, Ohio	54-In. hot strip mill, stand F-4, F-6	2	6,000

Types of motors purchased	Number of motors	Total horsepower
Alternating current motors	7	11,800
Direct-current motors	133	211,866
	140	223,666

(*Continued from page 175*)

conventional equipment. Lack of moving parts mean quiet, vibration-free operation.

Another means of developing electricity is thermionics. This is a converter which operates on the principle of the electron tube. As a cathode is heated, electrons bubble off and cross the vacuum to the anode. They then flow through the external circuit producing electric power.

Thus there are four new ways of turning heat into electricity: the thermionic converter, the fuel cell, the thermoelectric generator and the magnetohydrodynamics, or MHD units.

Ingot buggy operation by remote control is not new but there are a number of advanced features in the late units. In the new system at the Fontana plant of Kaiser Steel Corp., the soaking pit covers are operated from nine cover carriage stations located along the track. Each operator can start the buggy toward the laydown table when, but only when, it is one of his pits. Any operator can initiate an emergency stop signal. At the laydown table, an operator in the weighing and turnaround pulpit selects the pit to which the buggy is to be sent and starts it toward the pit. Slowdown, stopping and positioning are all automatic. Special features of the installation include an anti-collision system which will permit operation of two buggies at the same time, an indication panel on which lights show position of each buggy at all times, controls on the soaking pit operating platform identical with those in the pulpit, and duplicate installed spares of all equipment to make sure that all servicing can be done without lost time.

The first buck-boost electrical system to power an ore bridge was installed in 1960 at the Gary works of the United States Steel Corp. The design provides an effective economical means of using existing 250-volt. d-c constant potential power system to obtain ad-

justable-voltage drives. This type of design has been used in other applications but not on an ore bridge. This particular ore bridge has a bucket capacity of 22½ tons and a digging capacity of 1750 tons per hr. The drive has a 500-hp motor-generator set drive motor and three 200-kw generators with the generators electrically and mechanically interchangeable. For the usual adjustable voltage system, the ratings of each unit of the motor-generator set would have had to be doubled. The motors driving the individual motions receive half of their full-speed voltage from the line and the other half from the generators. The use of this technique cuts the ratings on the motor-generator sets by 50 per cent.

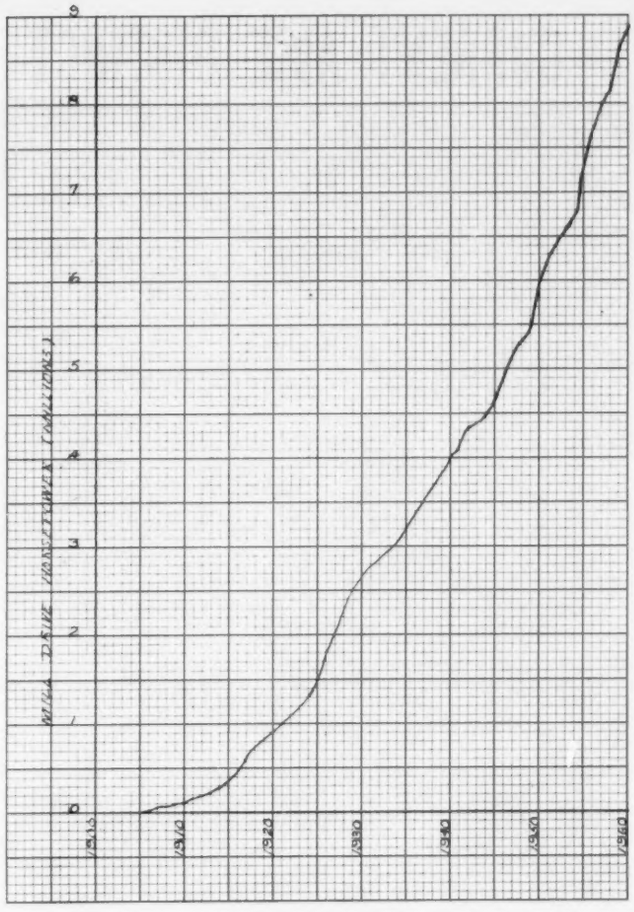
In many new installations where d-c power is not currently available, it is expected that a-c cranes may become standard. Analysis indicates that better crane life, lower maintenance and power savings may be obtained. As a result of this, there is extensive standardization work going on by the AISE to develop an a-c mill and crane motor. In application, it is expected that the a-c crane motors should be selected at about 15 per cent higher horsepower rating than if d-c were used. The motors will in general be higher speed units and, as a result, response time will be greater and an additional gear reduction may be required.

A foil-wound aluminum power transformer was built as a stepdown unit rated at 15,000 to 20,000 kva. It is built entirely from aluminum except for the core and a few mechanical accessories.

One of the big coming developments in the electrical field is going to be the use of much higher voltages in transmission lines. One company started operation of a short experimental test line with initial operation at 710,000 volts, a new high. This experimental line will have extensive instrumentation for recording test data to be taken for future use in design. The use of extra high voltage transmission lines should keep power costs down by minimizing transmission losses. Also, investment in such high voltage lines, because of the large blocks of power which can be carried, is expected to be more economical than in those operating at the more conventional lower voltages.

A late development in electrical installation is the so-called grouped-motor-control center. Among the innovations in such control centers are motor starter units with complete draw-out availability, stab-on connections for both power and control. The centers have positive unit-guidance and racking systems for starter units, double spring loaded power contacts to maintain connection even under fault, and a standard isolated and insulated vertical bus enclosed in a glass-polyester sandwich for dead-front protection. These control centers can handle NEMA sizes 1 through 6, motor starters for a-c or d-c motors up to 400 hp at 440 volts. The enclosures can be joined together, building block fashion, to centralize and protect the most complex systems of industrial auxiliary drives. The feeder breakers, distribution transformers, lighting panels, interlocking relays and meters also may be arranged for maximum convenience of the operator within the protected modular compartments of each control enclosure.

Another solution to obtain electrical installation economy is to have the electrical supplier do as much



Accumulative curve of main drive motors over 300 hp shows a total as of January 1, 1961 of 8,894,405 hp. One hundred and forty motors (223,666 hp) were added in 1960 of which 133 were direct current and seven were alternating current.

of the over-all electrical work as is practical in its factory. In line with this reasoning, Jones & Laughlin Steel Corp. installed on their Aliquippa works new continuous annealing line, the first power control room to be shipped by a manufacturer to the plant as complete units. The steel company needed only to connect to the a-c supply, make connections to the motors and miscellaneous equipment on the line, and wire to the operator's stations. It is reported that the design reduced overall installed costs up to 50 per cent. The power control rooms include a-c auxiliary control, d-c control, motor-operated rheostats, low voltage control, motor-generator sets and exciters and ventilating equipment.

It is believed that similar savings can be made on a number of other steel plant applications, such as processing lines, small rolling mills up to about 500 hp and the main motor-generator sets and main circuit breaker panels of large rolling mills.

Sales of main mill drive motors during the year were about half those sold in 1959. The horsepower of 140 main drive motors sold in 1960 totaled 223,666. Of this 73 motors with 122,566 hp were for domestic use and 67 motors with 101,100 hp were for foreign users. Of the motors sold, seven were alternating current and 133 were direct current. The accumulative curve of main drive motors having over 300 hp shows a total as of January 1, 1961, of 8,894,405 hp. ▲

CURRENT AISE DISTRICT SECTION MEETING NOTICES

BIRMINGHAM SECTION

Monday, February 27, 1961—Social Hour 6:30 P.M., Dinner 7:00 P.M., Meeting 8:00 P.M.

"Properties and Applications of Centrifically Cast Steel Tubing," by E. D. McCauley, Steel Foundry Superintendent, American Cast Iron Pipe Co., Birmingham, Ala.

Redmont Hotel, Birmingham, Ala.

BUFFALO SECTION

Tuesday, February 14, 1961—Dinner 6:30 P.M., Meeting 8:00 P.M.

"Future Economic Growth Niagara Frontier," by Rob Roy MacLeod, Commercial Vice President, Niagara Mohawk Power Co., Buffalo, N. Y.

Sheraton Hotel, 715 Delaware Avenue, Buffalo, N. Y.

CANTON SECTON

Monday, February 20, 1961—Social Hour 6:30 P.M., Dinner 7:00 P.M., Meeting 8:00 P.M.

"Power Sources of the Future," Dr. R. H. Boll, The Babcock & Wilcox Co., Research Center, Alliance, Ohio

Mergus Restaurant, Canton, Ohio

CHICAGO SECTION

Tuesday, February 7, 1961—Dinner 6:15 P.M., Meeting 7:45 P.M.

"New Electrical Devices for Steel Mills," by Dr. W. Mitchell, Director of Research, Allis-Chalmers Manufacturing Co., Milwaukee, Wis.

Phil Smidt's Restaurant, 1205 North Calumet Avenue, Hammond, Ind.

CLEVELAND SECTION

Tuesday, February 28, 1961—Dinner 6:30 P.M., Meeting 7:45 P.M.

"Power Systems for Increased Steel Mill Loads," by A. H. Knable, General Engineer, Allis-Chalmers Manufacturing Co., Milwaukee, Wis.

"Symposium on Conversion of A-C to D-C for Steel Mills."

"Static Power Equipment Method," by E. J. Cham, Power Conversion Engineer, Westinghouse Electric Corp., East Pittsburgh, Pa.

"Rotating Power Equipment Method," by Earle C. Barnes, Chief Engineer, Reliance Electric and Engineering Co., Cleveland, Ohio

Cleveland Engineering & Scientific Center, 3100 Chester Avenue, Cleveland, Ohio

COLORADO SECTION

Tuesday, February 21, 1961—Social Hour 6:00 P.M., Dinner 7:00 P.M., Meeting 8:00 P.M.

"Reassignment of Rolled Sections from 14-in. to 10-in. Mill," by R. Gordon Edgar, Assistant Superintendent—Roll Shops, The Colorado Fuel and Iron Corp., Pueblo, Colo.

Minnequa University Club, Pueblo, Colo.

DETROIT SECTION

Thursday, February 9, 1961—Dinner 6:30 P.M., Meeting 8:00 P.M.

The Detroit Edison Co. Night

"Modeling Steel Mills On A Digital Computer," by Wm. C. Wright, Specialist Metal Rolling and Processing Engineer, Apparatus Dept., Canadian General Electric Co., Ltd., Peterborough, Ontario, Canada.

Movie (to be announced)

Dinner—Cafeteria, General Office Building.

Meeting—Sales Auditorium, Service Building.

LOS ANGELES SECTION

Monday, February 13, 1961—Social Hour 6:30 P.M., Dinner 7:00 P.M., Meeting 8:00 P.M.

"Production of Oxygen and Its Use in the Steel Industry," by R. C. Barrett, Region Manager, Linde Co., Div. of Union Carbide Corp., Los Angeles, Calif.

Michael's Restaurant, 6309 E. Washington, Los Angeles, Calif.

PHILADELPHIA SECTION

Saturday, February 4, 1961—Dinner 6:00 P.M., Meeting 7:00 P.M.

"Steelton Facilities for Manufacturing of Expanded Line Pipe," by Frank Brecher, Superintendent of Fabricating Shop, Bethlehem Steel Co., Steelton, Pa.

"Blast Furnace Blower Selection—Axial and Centrifugal," by C. W. Dunn, Superintendent Utilities, Maintenance and Utilities Div., Fairless Works, United States Steel Corp., Fairless Hills, Pa.

Engineers' Club, 1317 Spruce St., Philadelphia, Pa.

PITTSBURGH SECTION

Monday, February 13, 1961—Social Hour 6:00 P.M., Dinner 7:00 P.M., Meeting 8:00 P.M.

"Precision Raw Material Inventory by Photogrammetry—Nuclear Methods" by Robert A. Cummings, Jr., Robert A. Cummings, Jr. & Associates, Pittsburgh, Pa.,

"Nuclear Methods for Moisture and Density Analysis" by Dr. O. K. Neville, Vice President, Nuclear Chicago Corp., Chicago, Ill.

"Some Recent Developments in Rolling Mill Equipment—Mash Welder for Light Gage Strip; Motorized Wedge Adjustment for Plate Shears; The Adjustable Width Plate mill," by W. L. Stover, Assistant Chief Engineer, Mesta Machine Co., Pittsburgh, Pa.

"Bar Mill and Strip Mill Loopers" by W. E. Kollek, Assistant Vice President—Engineering, Foundry & Mill Machinery Div., Blaw-Knox Co., Pittsburgh, Pa.

University Club, University Place, Pittsburgh, Pa.

ST. LOUIS SECTION

Wednesday, February 22, 1961—Social Hour 6:00 P.M., Dinner 7:00 P.M., Meeting 8:00 P.M.

"River Pollution as Affected by Industry," by Clair N. Sawyer, Director of Research, Senior Associate, Metcalf and Eddy Engineers, Boston, Mass., and Clarence W. Klassen, Chief, Sanitary Engineer, State Sanitary Water Board, State of Illinois, Springfield, Ill.

Elks Club, Granite City, Ill.

UTAH SECTION

Monday, February 13, 1961—Social Hour 6:30 P.M., Dinner 7:30 P.M., Meeting 8:30 P.M.

"Blast Furnace Modernization at Geneva," by L. Tofft, Division Superintendent, Blast Furnace Dept., Geneva Works, Columbia-Geneva Steel Div., United States Steel Corp., Provo, Utah.

Grandview Cafe, Provo, Utah

YOUNGSTOWN SECTION

Monday, February 27, 1961—Social Hour 6:00 P.M., Dinner 7:00 P.M., Meeting 8:00 P.M.

"What Is Your Maintenance Problem?" Panel discussion under direction of F. S. Ebinger, Acting Superintendent, Mechanical Dept., Republic Steel Corp., Warren, Ohio

Mahoning Country Club, Girard, Ohio

First in Heating Efficiency ... Pioneers in Furnace Design

FIRST Five-Zone, Continuous Reheating Furnaces were *built by RUST, in a 68" hot strip mill at a large eastern steel plant*

Since 1927, Rust has pioneered many 'firsts' in heating efficiency design including:

Two-Zone, Top-Fired Reheating Furnace → 1929
Three-Zone, Continuous Reheating Furnace → 1929
Four-Zone, Continuous Reheating Furnace → 1938
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Over 600 successfully completed contracts assure the most advanced heating efficiency for meeting your needs in the melting, reheating or heat treating fields.

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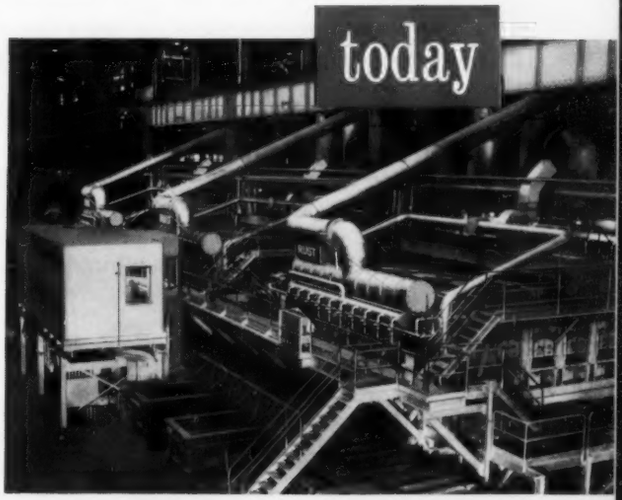

Modern, Five-Zone continuous reheating furnaces in 56" hot strip mill at a large eastern steel plant

RUST FURNACE COMPANY

930 Fort Duquesne Boulevard, Pittsburgh 22, Pa.

AMSCO ALLOY PART GIVES SLAG DIPPER THIRTEEN LIVES

User report: "Working in semi-molten slag at temperatures up to 1800°F., an Amsco "MML" alloy dipper front lasted 528 days. That's 13 times more service life than we got from the type previously used... which gave a maximum of only 40 days' service."

Amsco "MML" is a special combination of austenitic manganese and molybdenum, developed specifically for applications involving high temperatures as well as abrasion.

Amsco markets castings—not alloys. But we've developed a whole family of heat-shock-abrasion resistant alloys—in order to give you specific answers for each parts application problem. If you're replacing parts too often because they wear too fast, write or call us about *your* problem.

WITH PARTS LIKE THESE, AMSCO HELPS YOU HANDLE MORE TONS PER DOLLAR

Dippers • Buckets • Wheels
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Other Plants in: Denver • Los Angeles • New Castle, Dela. • Oakland, California
St. Louis. *In Canada:* Joliette Steel and Manitoba Steel Foundry Divisions

Figure 1 — Dortmund-Horder unit at Midland works is now in operation.

Crucible Steel Starts New Vacuum Degassing Unit at Midland Works

A NUMBER of heats of steel have been processed through the unique vacuum degassing unit at the Midland Works of the Crucible Steel Co. of America, and the results are generally encouraging.

The Crucible unit is unique in the North American Continent, and is the first vacuum degassing unit of its type. It was built by Lectromelt Division of McGraw Edison Co., Pittsburgh, Pa., licensee of Dortmund-Horder-Huttenunion A. G. of Dortmund, West Germany. A smaller unit, similar to Crucible's, is in operation in West Germany, applied to carbon steel production. Crucible, as a leader in specialty steels, is most interested in evaluating the contribution of the degassing unit to highly alloyed steels.

METHODS OF DEGASSING

Crucible teams of experts went to the European continent to investigate and study the three types of degassing units. These were:

1. Heraeus-Ruhrstahl siphon process.
2. Bochumer-Verein process—three modifications.
3. Dortmund - Horder - Huttenunion process.

The first process, the Heraeus-Ruhrstahl siphon, had not been commercially proven and did not seem to fulfill the requirement for specialty steel production. The process is accomplished by placing a ladle of molten metal under a vacuum vessel with two legs which extend below the slag line. Argon is pumped into one leg, creating a circulatory siphoning action.

The Bochumer-Verein process was a commercial process. There are three modifications of the process.

Ladle degassing.
Stream degassing—ladle to ladle.
Stream degassing—ladle to ingot mold.

The ladle degassing version would require a very large and expensive pumping system if large heats were to be degassed.

The more popular versions of the Bochumer-Verein process have been the stream degassing techniques. Here, the ladle is set above the unit. The molten steel is poured through a vacuum chamber into either another ladle or an ingot mold which is set in a lower section of the vacuum chamber.

The outstanding advantages of the Dourtmund-Horder unit are:

1. More complete mixing, and therefore more complete degassing.
2. Provision for adding alloying elements under vacuum.

OPERATION OF DORTMUND-HORDER PROCESS

In the process, a ladle of molten open hearth or electric furnace steel is moved by crane onto the trolley. It then moves under the vacuum chamber where it is weighed, so that proper alloying additions can be made if desired. The snorkel tube is then lowered. When the snorkel tube is below the layer of the slag, the pumping system is turned on, rapidly lowering the pressure in the chamber to about one mm. Now the 15-psi atmospheric pressure causes the liquid steel to rise about 60 in. above the level of the steel in the ladle. The unit is then lowered hydraulically. At this point, the molten steel in the snorkel tube spills into the vacuum chamber. When this happens, a large surface area of droplets of molten steel is exposed to vacuum. When the unit is raised, the steel which has been degassed flows back through the snorkel tube into the ladle.

The inertia of the steel causes it to

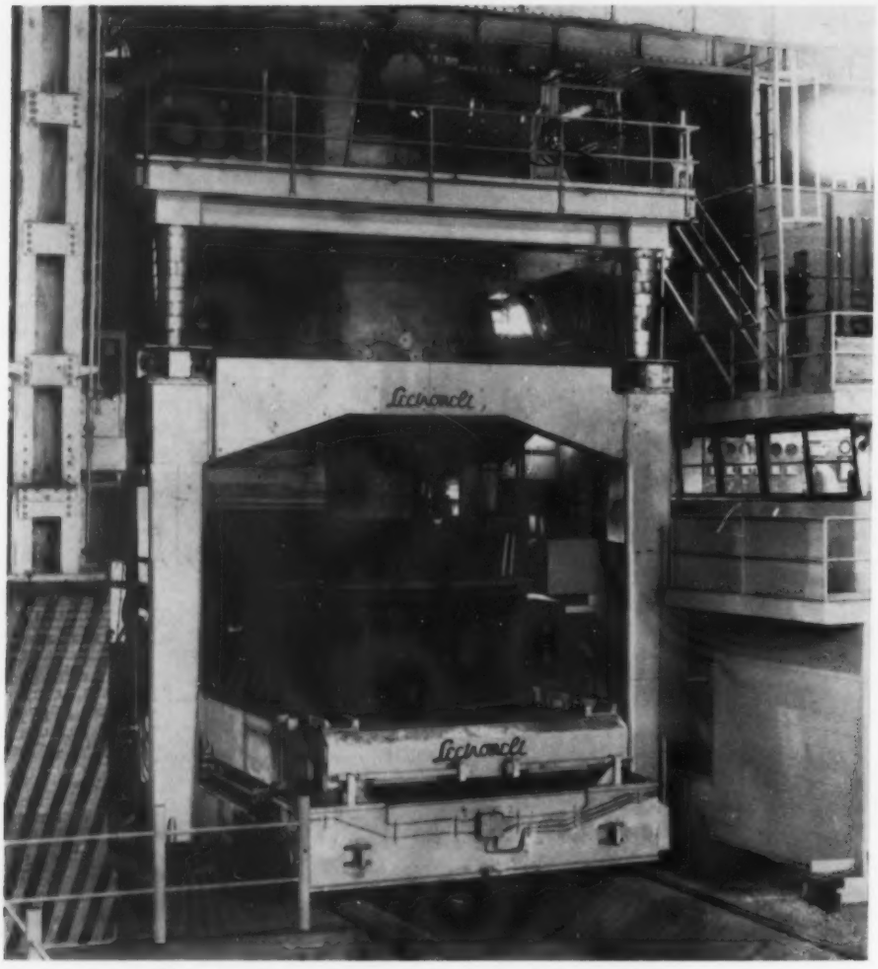


Figure 2 — Ladle is in place and snorkel tube in down position.

sink to the bottom of the ladle. When the cycle is repeated, untreated steel will rise into the unit. The unit is raised and lowered repeatedly, until the entire heat has been degassed. For a 170-ton open hearth heat, this takes approximately 30 min.

During the cycle, carbon heating rods maintain the vacuum chamber at proper temperature. Alloy hoppers around the rim of the vacuum chamber allow the addition of alloys to the steel under vacuum. The steel is deoxidized first. Then the alloying additions are made.

Aside from deliberate additions made during the process, the significant changes in chemistry which occur are as follows: First, the hydrogen is removed. Second, virtually all the oxygen is removed. Third, a large portion of the nitrogen is removed. Fourth, the carbon is lowered. The carbon is acting as a deoxidant, and the oxygen is removed as carbon monoxide and carbon dioxide. Fifth, some manganese is lost during the cycle. The composition may be adjusted either by compensation for the carbon and manganese losses in advance, or by adding these through the hoppers in the unit.

When the cycle is complete, the chamber is brought up to a partial pressure, using nitrogen, as a safety measure, before raising the snorkel tube to a point above the slag line where it is open to the atmosphere.

The Dortmund-Horder unit, although the most economical method of effectively vacuum processing an equivalent amount of steel, is an expensive piece of equipment. The additional processing in the unit must also add to the cost of the steel.

On the other hand, there are important potential savings which Crucible may be able to realize by the use of the unit. During this present evaluation, these economic factors are being studied very carefully.

Some of the potential savings which have been suggested are:

1. Elimination of the long slow cooling cycle customarily used for large sections of certain grades of steel.
2. Increase in yields resulting from better cleanliness of the steel.
3. Less use of alloying elements, since these can be added in the absence of oxygen, thus avoiding oxidation losses.

These factors will have to be studied over a considerable period of months before the projected savings can be weighed against the increased costs.

Just as it is too early to assess the possible benefits to the steel producer, so it is inappropriate to make any claims of the benefits of the unit to steel users. These will have to be proven during the evaluation period. However, Crucible does foresee a great many possible benefits of the unit.

1. The long soak currently used to eliminate hydrogen will be unnecessary. This should reduce the length of time from melt to delivery.

2. The removal of oxygen should definitely improve the cleanliness of the steels. The quality of steels processed in the Dortmund-Horder unit should be distinctly better than air-melted steels. It is anticipated that the improvement in cleanliness will result in:

   a. Improved transverse ductility.
   b. Better resistance to fatigue.
   c. Higher impact resistance—(lower ductile-brittle transition temperature).
   d. Greater reproducibility and reliability.

The factors will naturally be very important in many markets. Turbine rotors, bearings, die casting and plastic mold dies, constructional steels for aircraft and missile applications; these are all fields where Crucible feels that Dortmund-Horder processed steels will receive special attention.

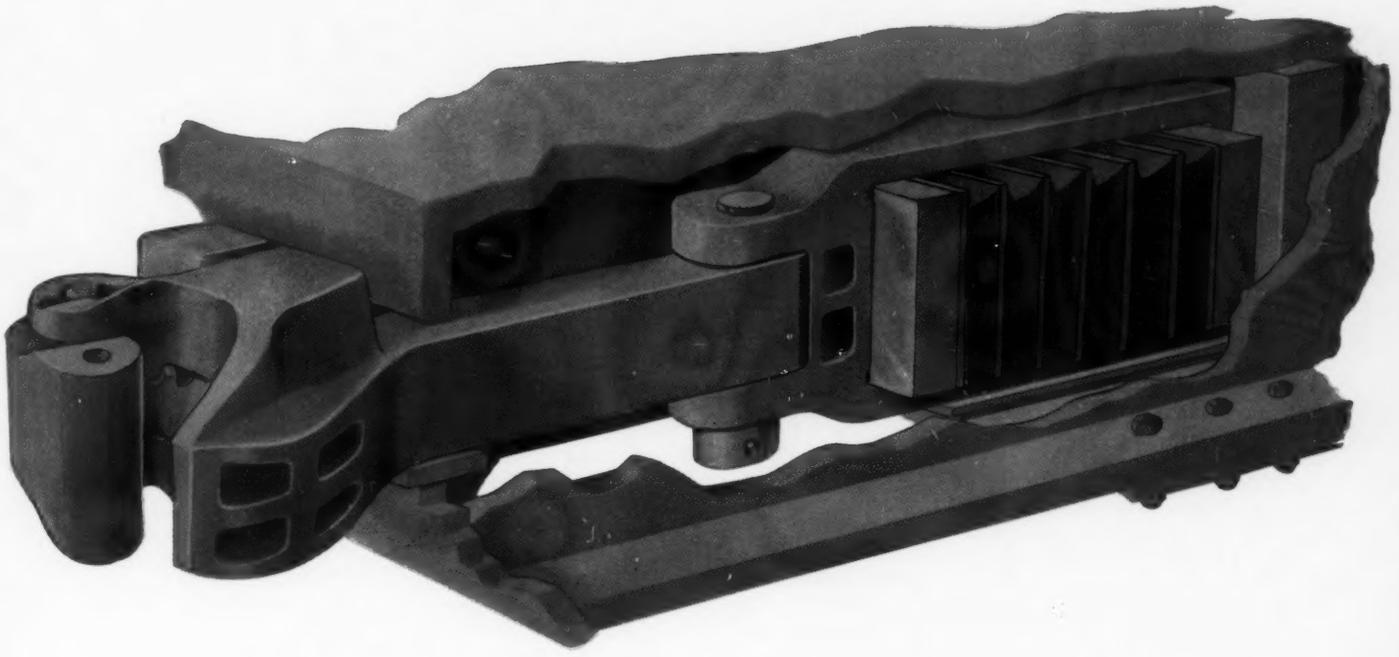
3. Closer control of chemical composition of several elements. This should be possible when oxidation losses are eliminated. If closer control of chemistries is possible, this will in turn mean more uniform response to heat treatment.

4. Reduction or better control of inclusions should provide better deep drawing, forming and surface finish in flat-rolled stainless steels. ▲

The ideal <u>combination</u> for industrial haulage

NATIONAL

SHARON-10A COUPLER RUBBER DRAFT GEAR



CUT MAINTENANCE AND CAR DAMAGE ON Slag Pot Cars
Charging Cars • Hot Metal Transfer Cars • Ore Transfer Cars

In industrial haulage, you can speed operations and at the same time slash maintenance and improve car availability by specifying <u>both</u> Sharon-10A Couplers and National rubber cushioning devices. Both units are based on National's proven designs in widespread use throughout the world on railroads and mine cars.

A-8A

NATIONAL MALLEABLE and STEEL CASTINGS COMPANY

Established 1868

Transportation Products Division
Cleveland 6, Ohio

International Division Headquarters
Cleveland 6, Ohio

CANADIAN SUBSIDIARY
National Malleable and Steel Castings Company of Canada, Ltd. Toronto 2-B, Ontario

COUPLERS • YOKES • DRAFT GEARS • FREIGHT TRUCKS • JOURNAL BOXES
NATIONAL SPEEDLOADER CONTAINER HANDLING SYSTEM

Experimental Transmission Line To Operates at 750,000 Volts

THE United States bolted ahead of Russia as the world leader in extra - high - voltage transmission when the General Electric Co. put approximately three-quarters of a million volts on its prototype extra-high-voltage system near Pittsfield, Mass.

This operating voltage represents the highest ever attained on a transmission line. The Soviet's highest experimental line is reportedly at 600,000 volts. Transmission voltages in use in the United States today range from 115,000 to 345,000 volts.

The record energization took place at General Electric's Project EHV (extra - high - voltage), a 4.3-mile prototype transmission system divided into a north and south section. The world's highest voltage was applied to the north section. The southern portion will be energized next year.

Project EHV is in operation to help utilities solve numerous problems involved in constructing future extra-high-voltage lines. Such higher voltage is a sensible, economical way to help supply America's demands for twice as much power within the next 10 years. A 750,000-volt line will transmit over six times as much power as six 115,000-volt lines. Savings in construction costs, buying expensive rights-of-way, towers, conductors and electrical apparatus result. This will help utilities offer continued economical rates in the face of rising costs.

Twelve companies are contributing to the $7,500,000 project, coordinated by General Electric's Power Transformer Dept., Pittsfield. An advisory council, composed of executives and engineers from 15 United States and Canadian utilities, and a consulting engineers committee, numbering engineers from 14 U. S. consulting engineering firms, are lending assistance.

The new techniques used at Project EHV were predetermined by three years of extensive analytical studies, computer and model investigations and laboratory work. They will be verified under actual field conditions. If some of the technology needs correction or refinement, it will be more economical on an experimental line, such as Project EHV, than on a utility's fully-constructed operational system.

The prototype system carries 267 instruments for the measurement of electrical, mechanical and radiological effects on the system. Checks will be made on the project's radio and television influence and the effects of temperatures, rain, wind, contaminating particles and humidity. Corona losses, known to reduce system efficiency by 50 per cent, will also be measured.

Project EHV wants to be hit by lightning. Huge 40-ft lightning rods atop the transmission towers attract lightning strokes that might narrowly miss the line. Later an impulse generator will be installed to shoot man-made lightning bolts of 3,000,000 volts to the line, without having to wait for a lightning storm to pass over.

Radio-active material is buried directly under the EHV line to measure the earth's magnetic forces during periods of severe weather.

The most up-to-date data processing system of its type in the world reads and evaluates measurements at 20-min. intervals in good weather and at two-minute steps in bad weather. This averages out to 10 readings per hour for a total of more than 10 million annual readings.

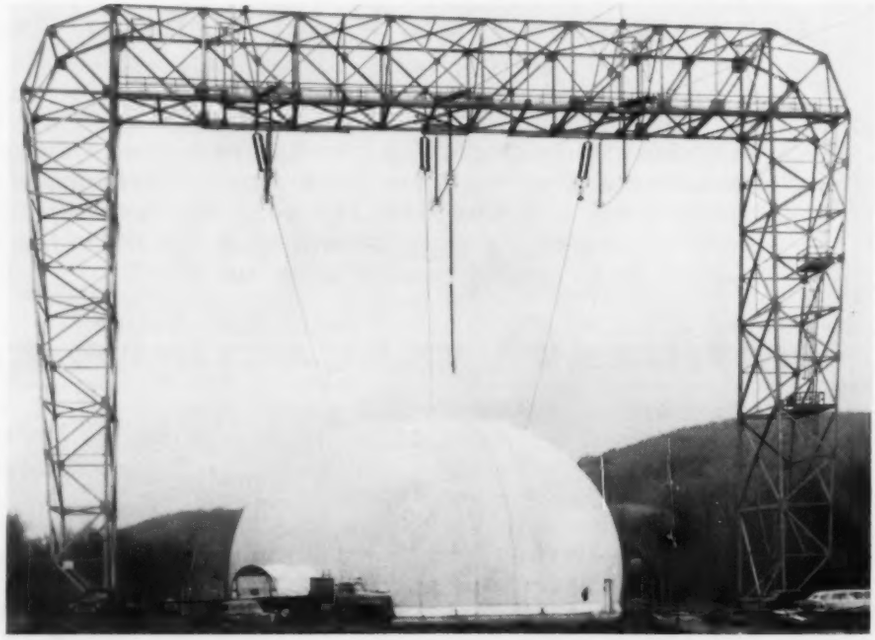
At the terminal building the data is recorded on punched paper tape, converted to magnetic tape, and processed in a 705 computer to provide the technical information in the form required for rapid, comprehensive analysis.

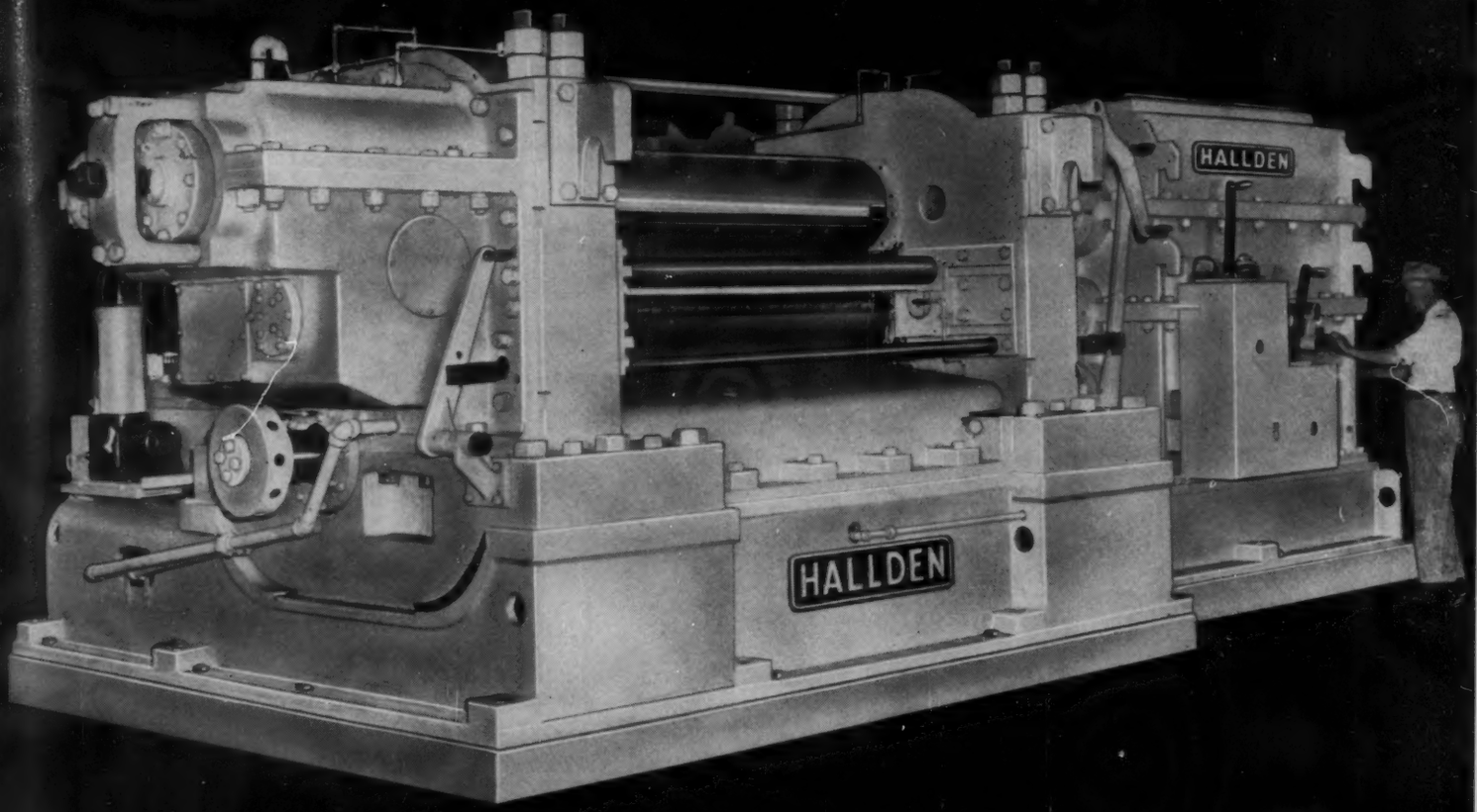
The project draws its power from a nearby Western Massachusetts Electric Co. 115,000-volt line. Connection is made at the project substation, through disconnect switches, to a three-phase airblast circuit breaker and then to a 4,000,000-volt amp regulating transformer. Voltage is then stepped up by the world's highest voltage power transformer to a range of 460,000 to 750,000 volts. All units are supplied by General Electric.

General Electric insulators that can withstand a tension of 36,000 lb hold the conductors, supplied by Aluminum Co. of America, below the transmission towers.

The towers, designed by American Bridge Div. of United States Steel, are the world's largest transmission structures. Tower number two weighs 134 tons, is 128 ft high and 182 ft wide. Towers one and three are somewhat smaller. ▲

Figure 1 — Man-made lightning of 3,000,000 volts will shoot from within this bubble and bombard conductors at Project EHV (extra-high-voltage).





SYNCHRONIZED ROTARY SHEET SHEARS

Combine Accuracy, Speed, Durability

- **Infinite length-of-cut control**
- **Full synchronization**
- **Minimum adjustment**
- **Reliable performance**

All these features are assured by such Hallden design extras as hardened torque correcting surge gears, dynamically balanced components, precision fitted parts.

Hallden shears are engineered and built to meet the requirements for the most modern high speed strip processing lines.

For custom designed synchronized flying shears for all high production strip shearing, consult Hallden, the worlds foremost designers of flying shears.

HALLDEN

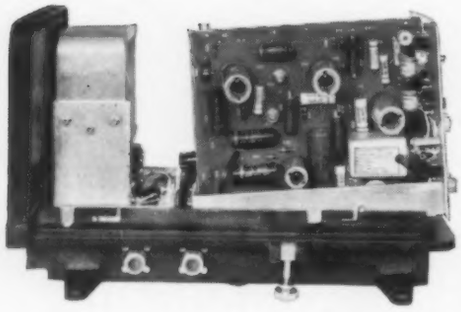
The world's leading machinery manufacturers rely on Hallden shears in their process lines

THE HALLDEN MACHINE COMPANY • THOMASTON, CONNECTICUT

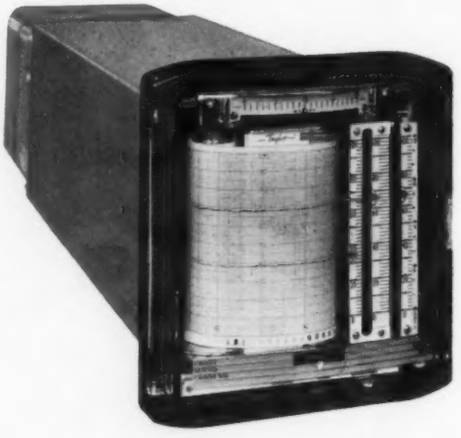
Associates: The W. H. A. Robertson & Co., Ltd., Bedford, England

FROM TO

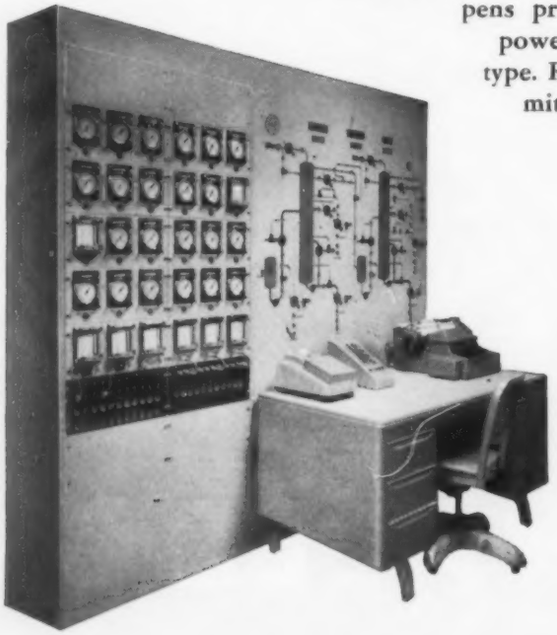
From simple temperature measurement to a complete Scanning and Logging system . . . you get accurate, dependable instruments when you specify Taylor



700T Potentiometer Transmitter
Converts a DC primary electrical signal into a 3-15 psi pneumatic output for controllers and receivers. Continuous, electronic standardization eliminates slide wires, batteries and moving parts. Plug-in service "cans" permit instant conversion from one type of service to another. Ask for **Bulletin 98262.**



90J TRANSCOPE* Recorder
Most convenient, most compact recorder yet developed for modern instrument panels. Front-of-panel control settings permit easy adjustment while recording. "Servomatic" power pens provide 150 times more power than bellows-actuated type. Responsiveness to transmitter output is 0.1%. Ask for **Bulletin 98286.**



Taylor TRANS-SCAN-LOG* Control System
Interlocks scanning and logging with process control, enabling an operator to instantly visualize, evaluate and act upon any processing irregularity as it occurs. Scans and logs up to 650 points of measurement. Proven dependable in over three years of field service, the TSL System meets today's requirements for complete process supervision with minimum manpower. Ask for **Bulletin 98268.**

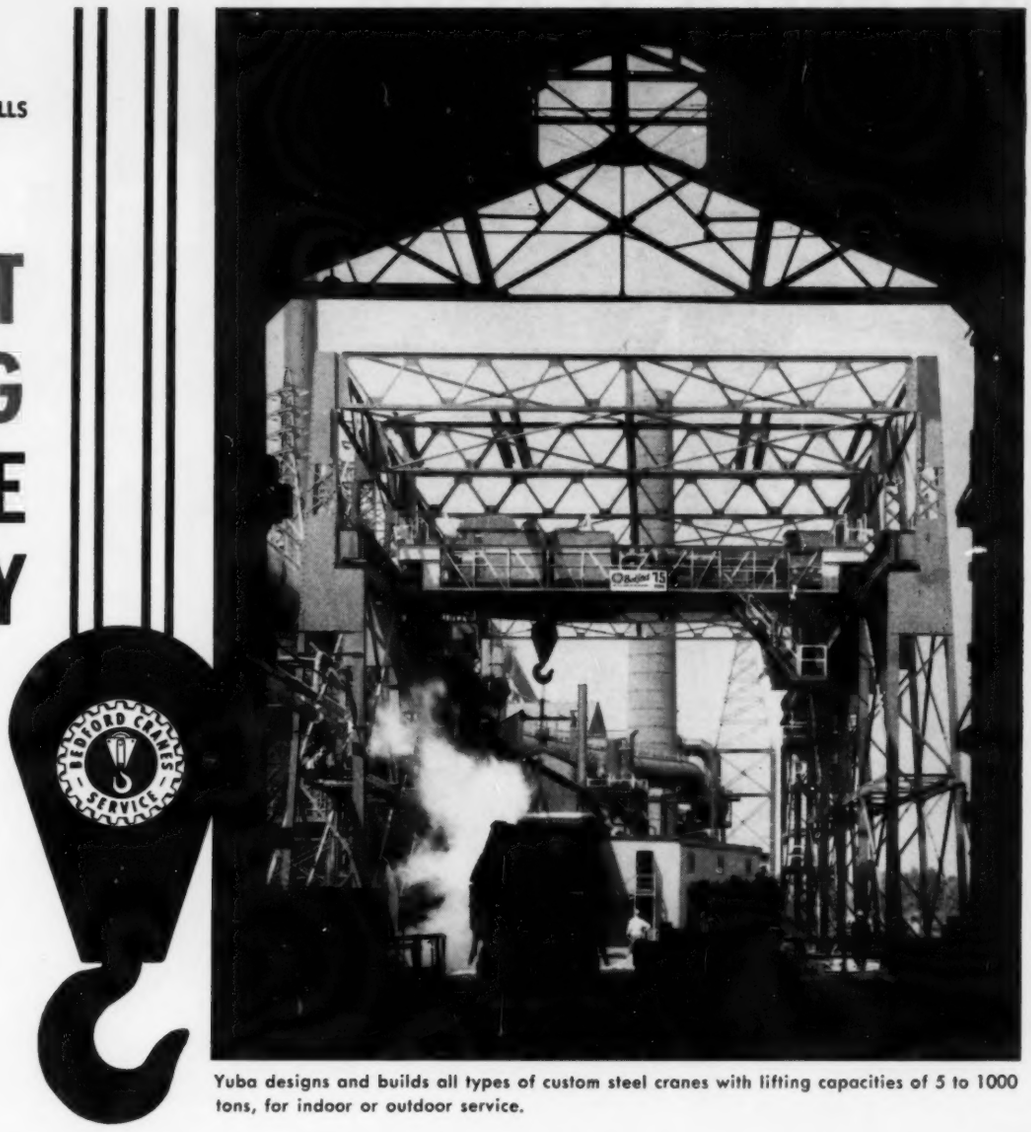
Call your Taylor Field Engineer or write for Bulletins. Taylor Instrument Companies, Rochester, N.Y., and Toronto, Ontario.

*Reg. U.S. Pat. Off.

***Taylor Instruments* MEAN ACCURACY FIRST**

IN STEEL MILLS

WEIGHT LIFTING MADE EASY



Yuba designs and builds all types of custom steel cranes with lifting capacities of 5 to 1000 tons, for indoor or outdoor service.

Yuba-Bedford Steel Mill Cranes are working to plant capacity —24 hours a day —year after year

Two generations of steel makers have operated Bedford Cranes in mills from Pennsylvania to Peru. These are mills where the handling jobs are tough—where cranes work shift after shift under all conditions —and where there's time for only routine maintenance.

Hundreds of Bedford Cranes have been manufactured for leading steel producers...cranes that are specially designed and custom-built by Yuba to the tough requirements of the steel industry. Big lifting problems are made easy on every shift—for years!

Yuba designs, builds and erects all types of cranes including bridge, unloading and material handling, gantry and semi-gantry, floating and jib cranes. Also derricks, hoists and launching towers for defense ordnance.

YUBA

specialists in steel mill cranes and custom cranes of all types

YUBA-BEDFORD CORP.

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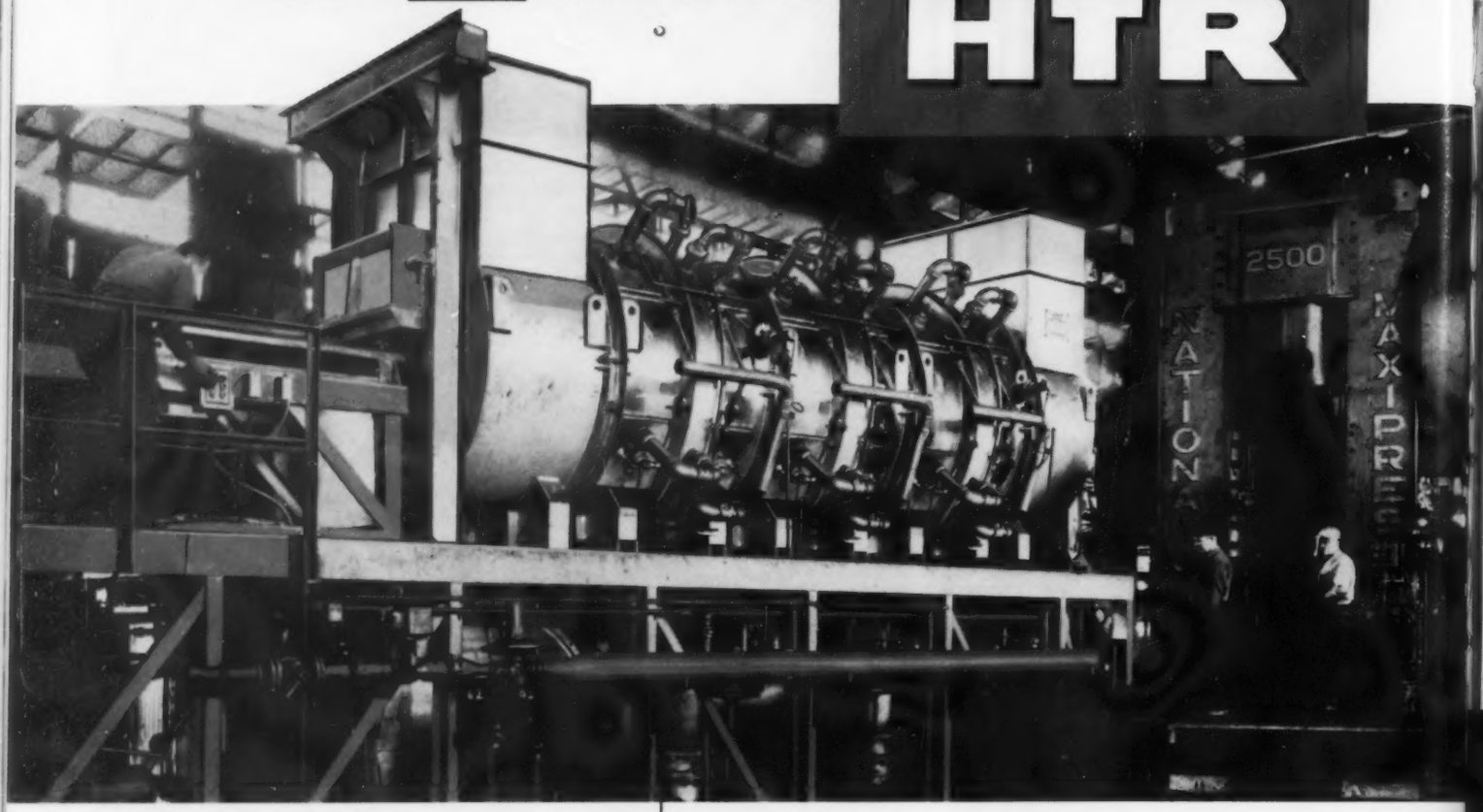
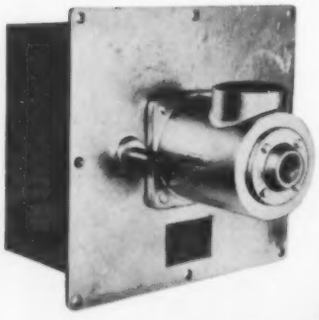
HIGH-SPEED HEATING

at its BEST with the . . .

BLOOM HTR

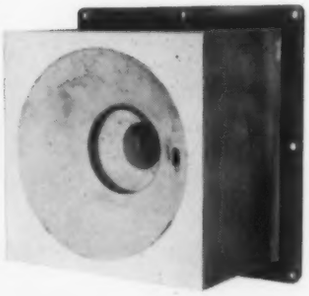


Courtesy of Gas Machinery Co.



No metallic parts exposed to high temperature.

Contoured port block gives high temperature radiating surface with no forward flame velocity.



Bloom HTR Burners were selected by the furnace builder to fire this high speed pusher type forge furnace. High heat release without flame impingement on the product and adaptability to furnace shape made the HTR Burner ideal for the job. Here are the results:

OPERATION

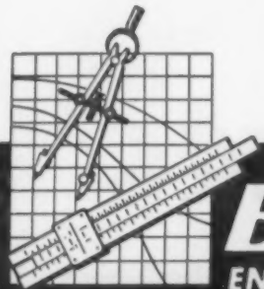
Material	4" cubes
Production rate	8000 lbs. per hour
Heating time	8 minutes—2 minutes per inch
Furnace temperature	2650°F
Scale condition	so light that no special scale removal equipment is needed.

MAINTENANCE

No furnace repairs } in first year
No burner or port block maintenance } of operation.

Other successful HTR Burner applications include:

- Tube Upsetting
- Continuous Strip Pre-Heating, Annealing, Coating, and Drying
- Batch type Forging
- Aluminum Chip Melting
- Glass Melting



BLOOM
ENGINEERING CO., INC.
857 W. North Avenue Pittsburgh 33, Pa.

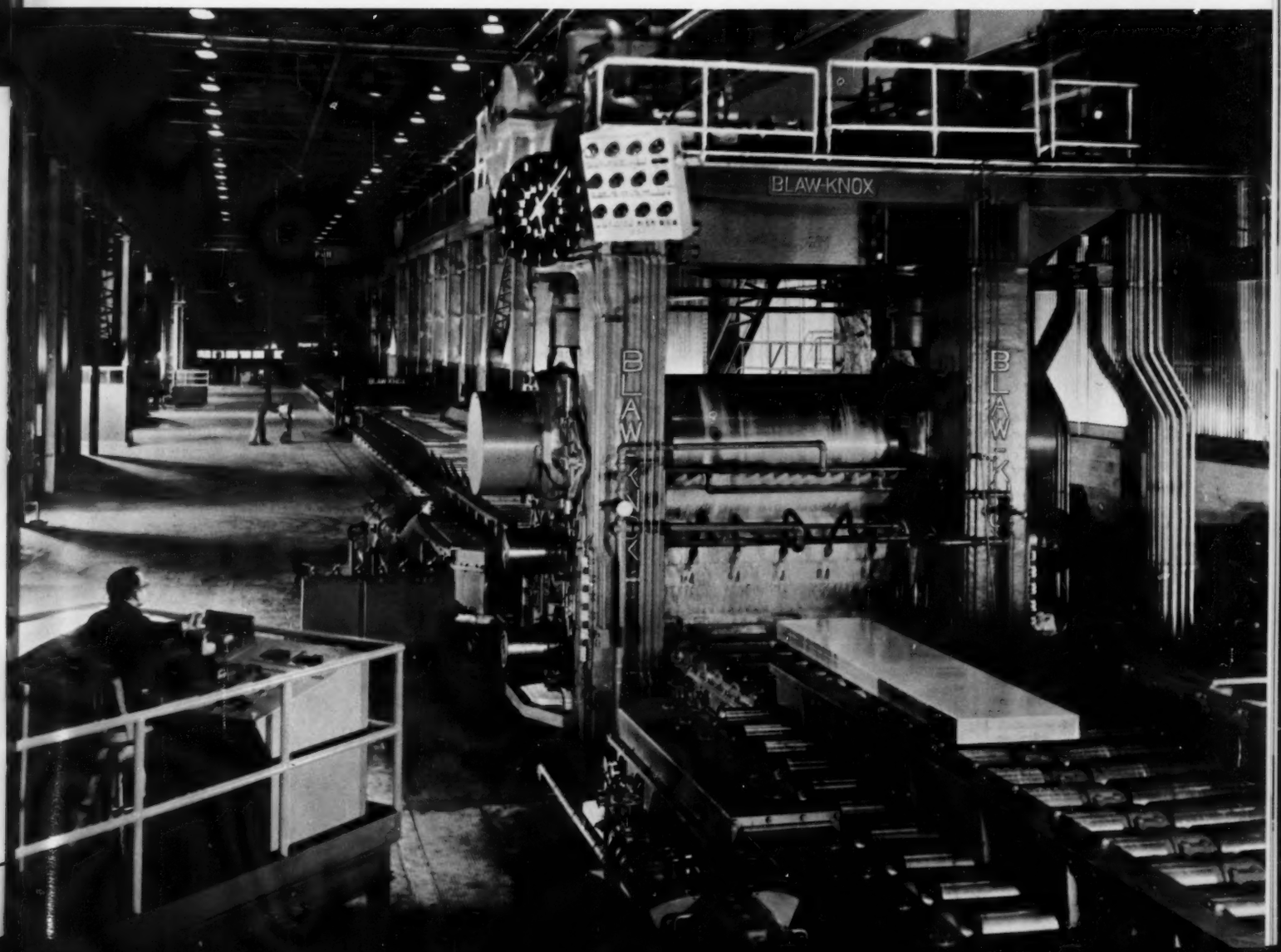
ENGINEERING EXPERIENCE EQUIPMENT

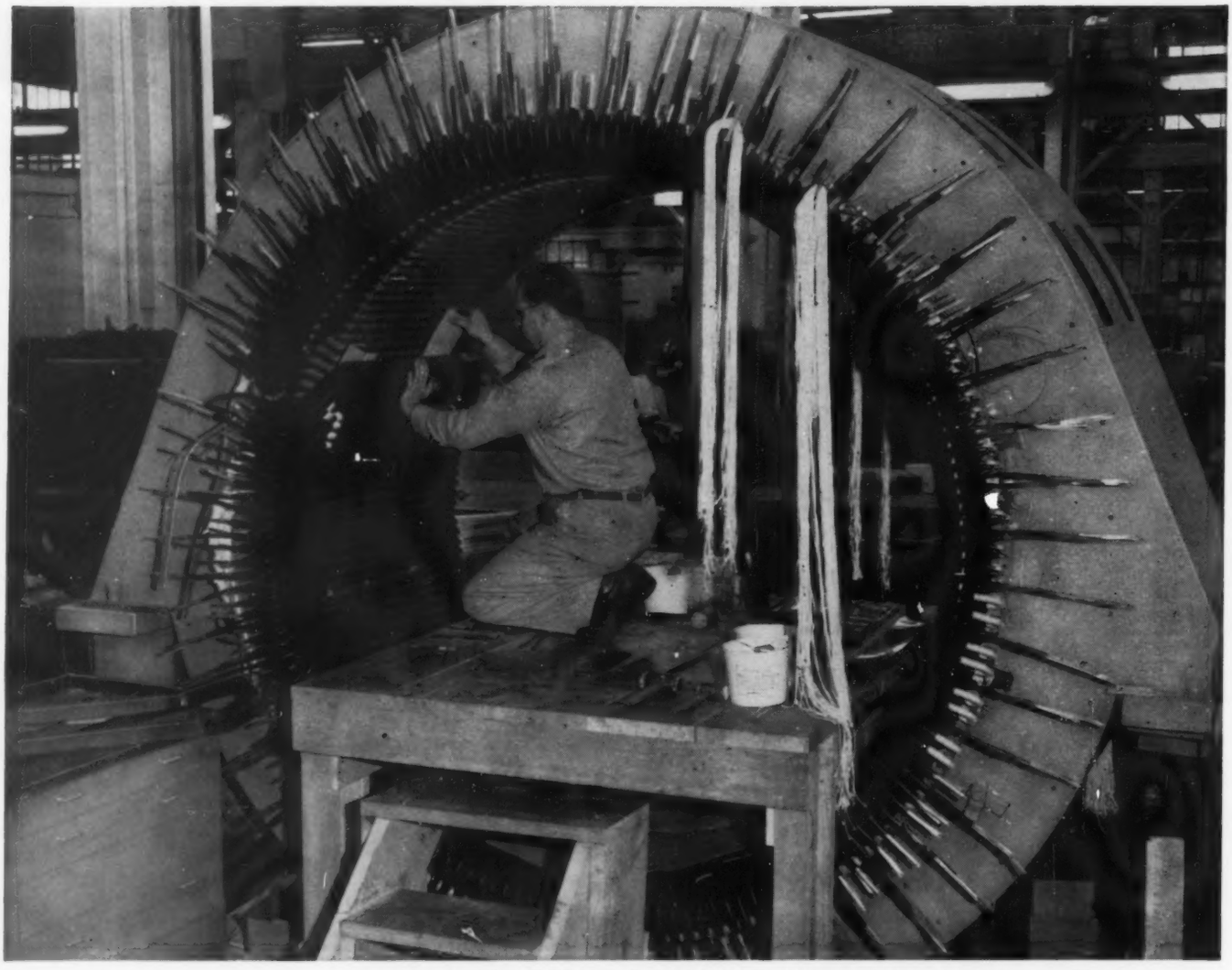
BLAW-KNOX

Aluminum Reduction Mills

Blaw-Knox designs and builds a full range of mills for the reduction of aluminum and other non-ferrous metals. Other Blaw-Knox equipment for the metals industry includes complete rolling mill installations and auxiliary equipment for ferrous and non-ferrous metals, sheet and strip processing equipment, electrolytic tinning, annealing, and galvanizing lines, seamless pipe and tube mills, draw benches, and cold draw equipment, Blaw-Knox Medart cold finishing equipment, iron, alloy iron and steel rolls, carbon and alloy steel castings, fabricated steel plate or cast-weld design weldments, steel plant equipment, and heat and corrosion resisting alloy castings. Blaw-Knox Company. Foundry and Mill Machinery Division, Blaw-Knox Building, 300 Sixth Ave., Pittsburgh 22, Pennsylvania.

32- and 56-inch x 96-inch, 4-high reversing hot strip mill.





Installing NECCOBOND coils in 4000 HP, 400 rpm, 6600-volt stator of mill drive motor.

NECCOBOND insulation system protects motors in severe environments

Completed winding passes 23,000-volt test.

Provides optimum resistance to moisture, heat, corrosive atmospheres

NECCOBOND is specified for rewinding many big rotating machines, like this 6600-volt steel mill motor, that have to perform in rugged environmental conditions.

NECCOBOND is based on time-proven insulating materials—mica and glass. These are welded by a special impregnant into a tenaciously bonded, resilient, voidless insulation wall. A unique method of fabrication assures homogeneous insulation.

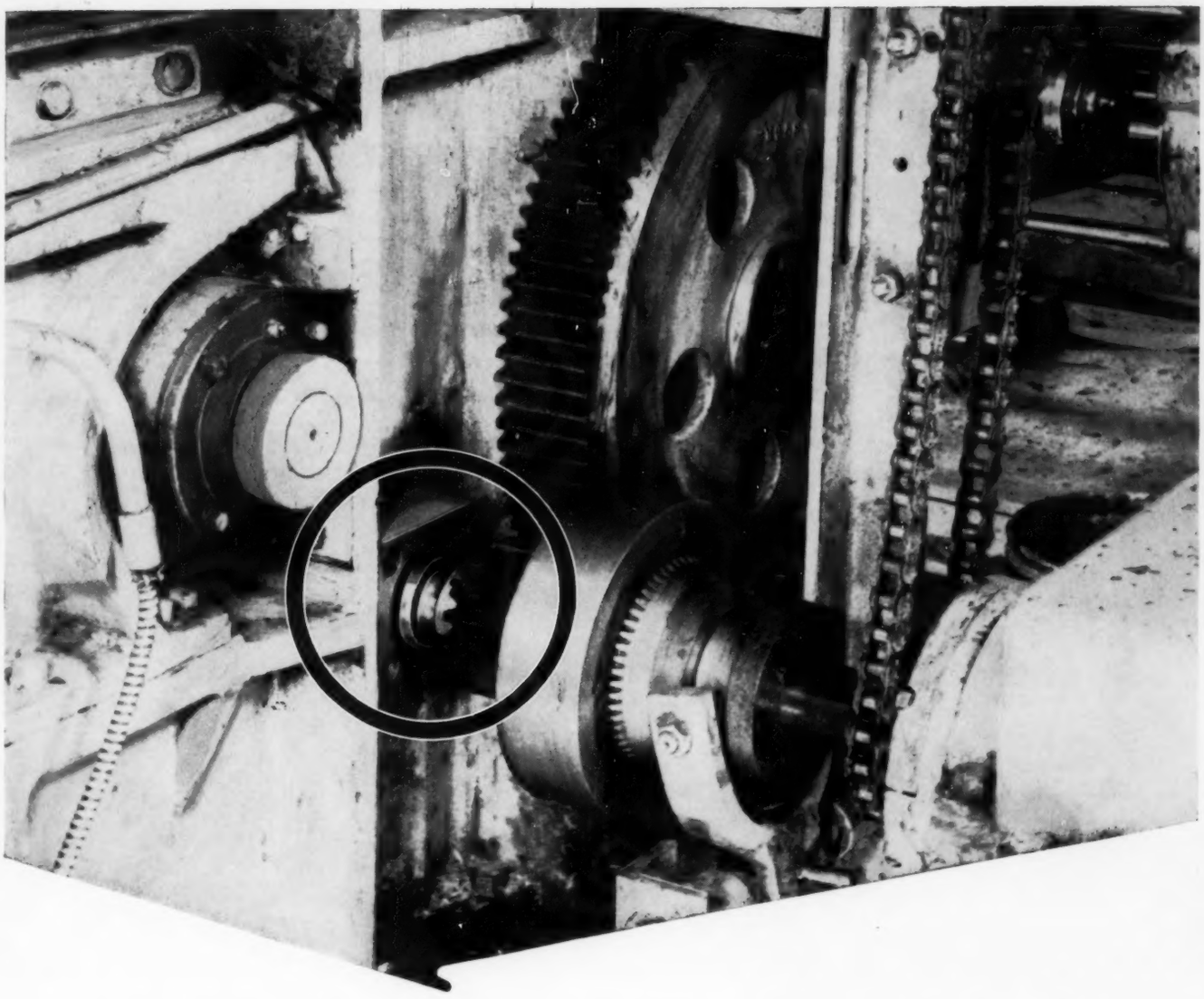
When you require rewinding or rebuilding of your heavy duty motors, particularly where moisture, heat, or corrosive atmospheres are encountered, specify NECCOBOND. For information call National's Columbus plant... HUdson 8-1151... or check the nearest National field engineer.

NATIONAL COILS

National Electric Coil

COLUMBUS 16, OHIO • IN CANADA: ST. JOHNS, QUEBEC

DIVISION OF McGRAW EDISON



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The original bearings on the pinion drive of this corrugating machine had an average life of only three months. Our customer had been advised that only a complete engineering change of machine drive would solve the problem.

Our engineers refused to accept this verdict and after much research found a standard, double row, roller bearing that, plus a standard adaptor, would fill all dimension requirements and give the radial capacity necessary for trouble-free operation.

We solved this bearing problem (as we have solved countless others) because we are authorized distributors for all nationally-known makes of bearings. We know the characteristics of each type of bearing and our recommendations are backed by many years of experience.

When you need bearings for any purpose, call the branch nearest you. We have the most extensive, the most complete stock of bearings and bearing accessories in the world ready to serve you.

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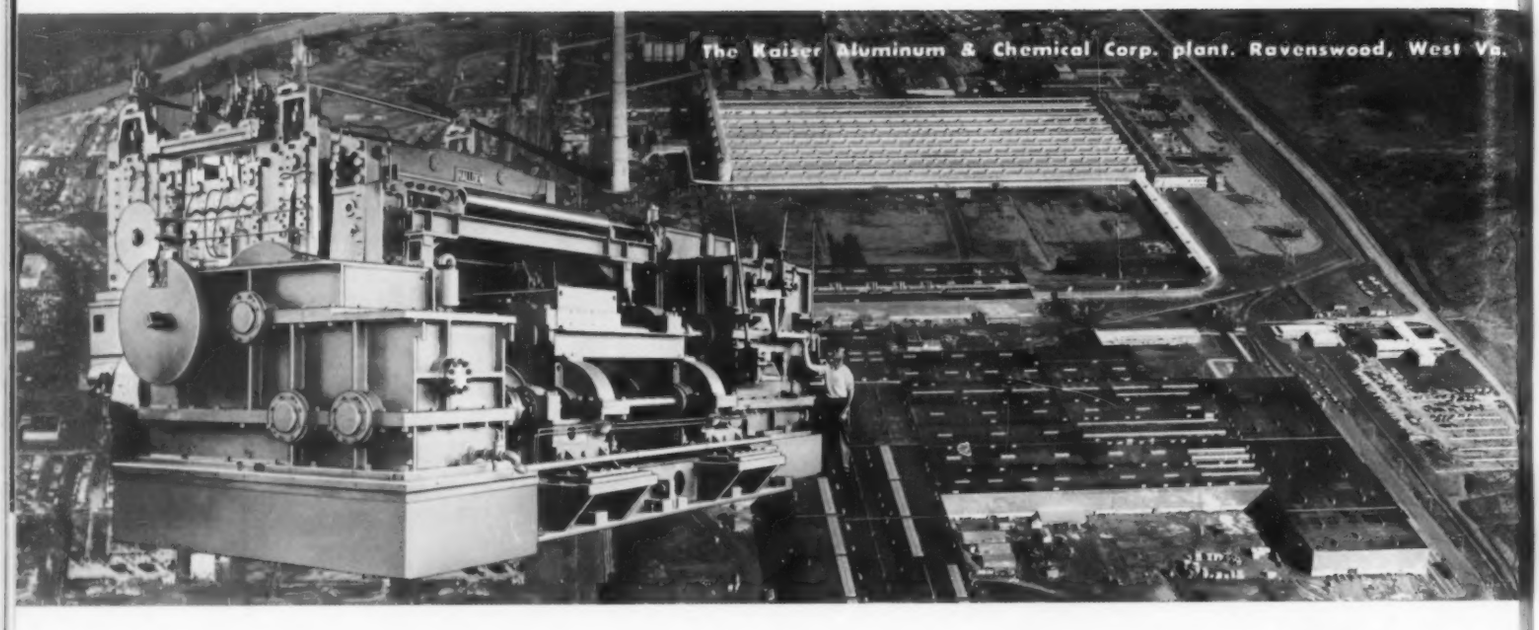
KAISER ALUMINUM & CHEMICAL CORP. uses

on this new Hallden . . . the

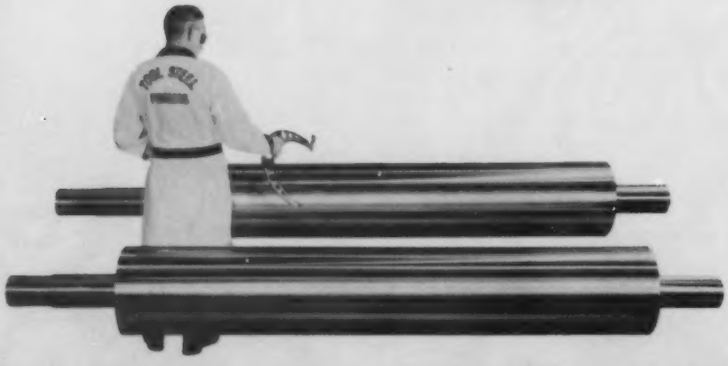


The Kaiser Aluminum & Chemical Corp. plant, Ravenswood, West Va.

the complete complement of pinch, leveller and feeder rolls on this Hallden shear are TSP hardened rolls

these are TSP rolls being inspected before installation on Hallden shear

feed rolls



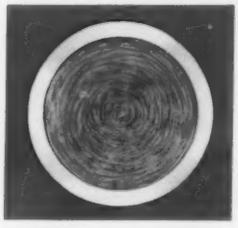
leveller rolls

TSP hardened rolls

world's largest flying shear!

The Kaiser Aluminum & Chemical Corporation's previous experience with "Tool Steel Process" hardened products as replacement items, is one of the reasons for purchasing TSP rolls as original equipment on their new giant Hallden shear at their ultra modern plant in Ravenswood, West Virginia. Kaiser Aluminum, like many leading companies, uses TSP hardened products because they reduce operating costs. They last many times longer, eliminating the necessity of frequent replacements. They cut expensive downtime because it is seldom necessary to stop a machine to replace a long wearing "Tool Steel Process" product.

TSP rolls are available in all sizes and shapes for all cold processing operations. They are hardened by our special process. A file hard surface to full depth of permissible wear gives maximum life. The core, refined for toughness and ductility, gives maximum strength. Each TSP roll carries a positive written guarantee that it will last longer in the same service than any other product. Photo on right is section through leveller roll. Note deep hard case (95 to 100 Scleroscope). The hundreds of TSP products for the Industry include gears, pinions, rolls, wheels, arbors, shafts and axles, sprockets, mill pinions, screwdown screws, etc. Product Bulletins available on request.



THE TOOL STEEL GEAR AND PINION CO.
CINCINNATI 16, OHIO

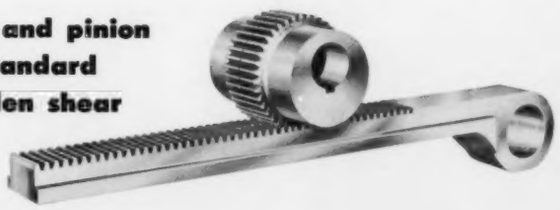
MEMBER OF AGMA

The Standard of Quality Since 1909 for Gears, Pinions, Rolls, Wheels and Other Hardened Products.

AD 1042—Printed in U.S.A.

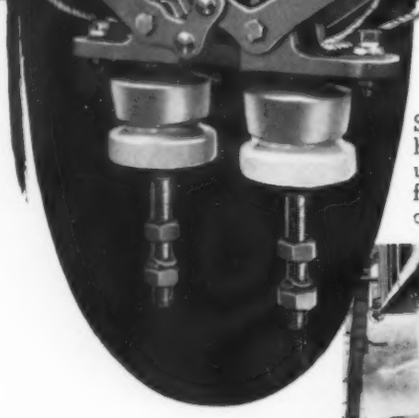
pinch rolls

rack and pinion for standard Hallden shear

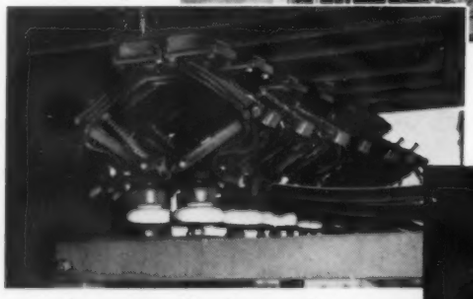


helical pinions for standard Hallden shear

U.S. Steel's new towering 629-foot ore bridge designed and built by American Bridge for National Tube Division's Lorain, Ohio, Works.



Shown below are the copper-head steel rails. These unusual conductors feature steel for strength and copper for current capacity.



Above are the specially designed pantographs, with carbon shoes, which maintain constant contact with the copper contact surface of the conductor rails under all operating conditions.

Chosen for its low maintenance and freedom from past conductor system difficulties; this Ringsdorff Current Conductor System is now an integral part of the great ore bridge at the Lorain Works of U.S. Steel. Ringsdorff Current Conductor Systems are easily adaptable to any normal or special application in American Industry.

The Ringsdorff Current Conductor System is now being manufactured in the United States.

For specific engineering assistance, contact:

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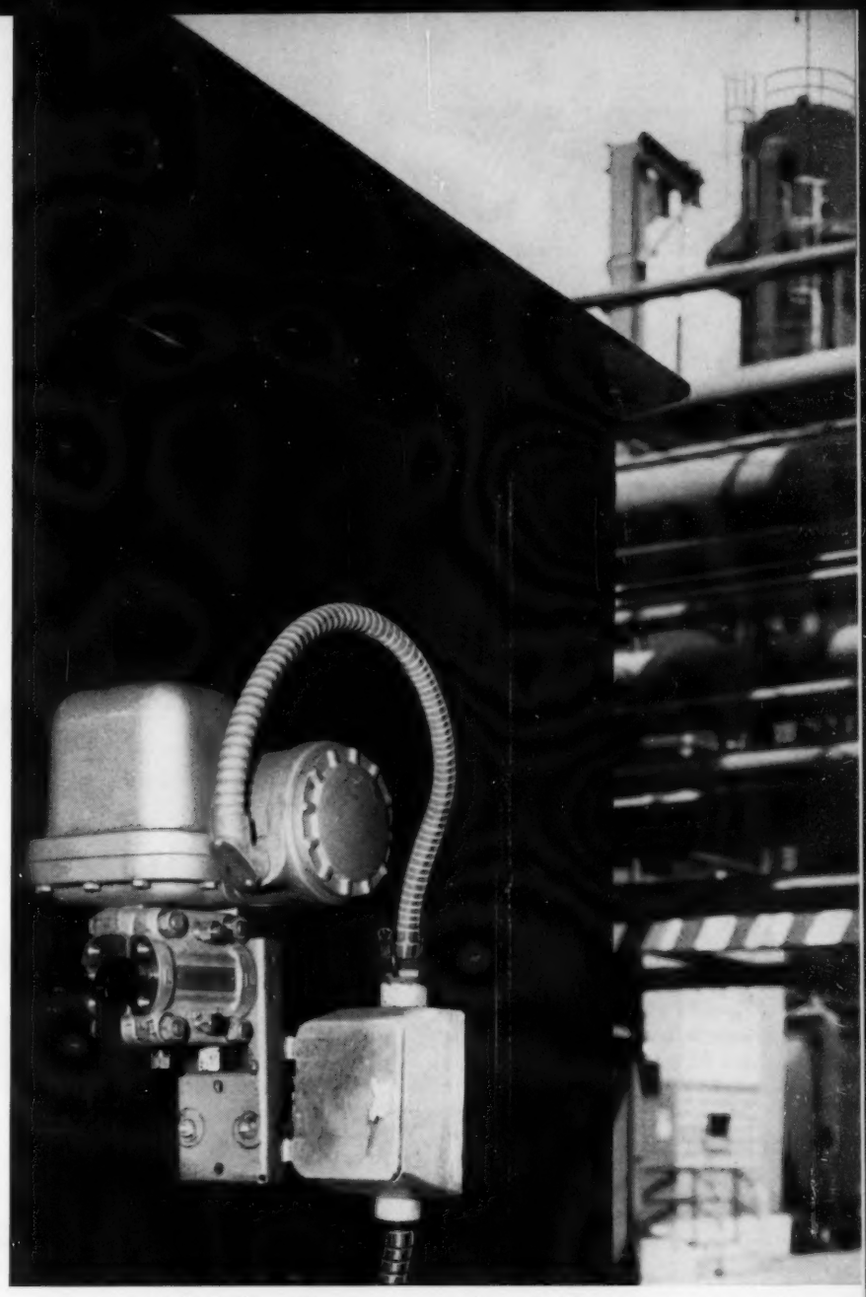
Foxboro electronics help giant steel mill "optimize" distribution of utilities

Water, gas, steam, power, oxygen — it takes all types of utilities to operate a modern steel mill. And any improvement in the efficiency of their distribution can reap a rich harvest in savings.

Foxboro Electronic Consotrol* instruments are helping one major producer reap just such a harvest. Dozens of Foxboro Electronic Transmitters scattered over the giant steel mill, flash pressure, level, and flow variables to a central, computer-directed, dispatching control center. As the computer figures optimum utility distribution, operators put it into effect.

Foxboro Electronic Consotrol transmitters were a natural for the system. They transmit for miles, instantaneously — over a simple pair of unshielded wires. No field power supply is required. Their 10-50 ma d-c signal serves as input for both computer and Consotrol recorders. And since components are all solid-state there is no problem of maintenance.

Foxboro Electronic Consotrol instruments cover the entire control loop. Transmitters, receivers, controllers, valve operators—everything needed for today's most advanced control techniques. Ask your Foxboro Field Engineer for complete details. Or write for Bulletin 21-10, The Foxboro Company, 581 Neponset Avenue, Foxboro, Mass. *Reg. U. S. Pat. Off.*



▲ One of 44 Foxboro Electronic transmitters flashing data to central dispatching station. Exclusive diaphragm construction prohibits transmitter from being damaged by overrange.

Foxboro Electronic Consotrol recorders at central dispatching station, are "plugged" in only when computer typewriters show an upset. Switchboard allows 16 recorders to cover 44 different transmitting stations.

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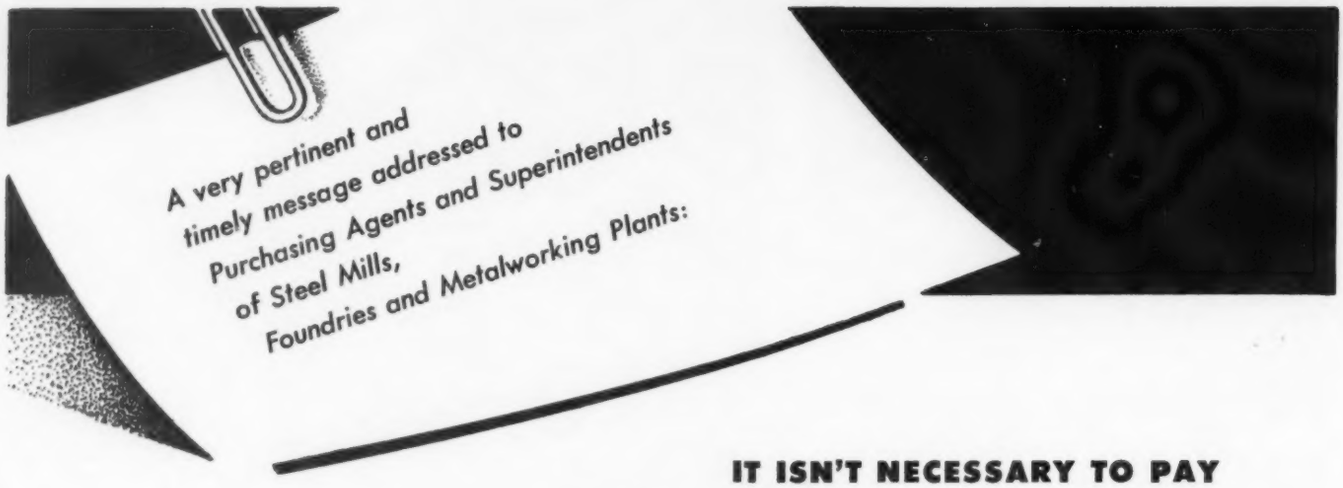

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Date-line Diary...

December 1

Δ The American Iron Ore Assn. reports that shipments of iron ore down the Great Lakes in November, 1960, totaled 1,942,980 gross tons compared with 5,420,904 tons in November, 1959; season shipments to December 1, 1960, totaled 69,631,789 gross tons compared with 43,705,501 tons to December 1, 1959.

December 2

Δ Auto assemblies in November, 1960, totaled 597,116 cars.

Δ Five Florida frozen juice processors announced they will need 375,000,000 aluminum cans this season, representing more than 20 per cent of the containers the frozen concentrate pack will require.

Δ The Bureau of the Census, Dept. of Commerce, reports that production of titanium mill products in September, 1960, totaled 944,553 lb compared with 963,908 lb in August, 1960, and 365,734 lb in September, 1959.

December 5

Δ The AISI reports that the operating rate of the steel industry for the week of December 5, is scheduled at 1,376,000 tons (48.3 per cent of capacity). This compares with 1,393,000 tons one week ago (48.9 per cent capacity) and 2,732,000 tons one year ago. Index of production for the week is 95.7.

Δ The Bureau of Mines reports that production of Pennsylvania Anthracite for November, 1960, totaled 1,650,000 net tons compared with 1,612,000 tons in October, 1960, and 1,863,000 tons in November, 1959.

December 6

Δ Auto sales in November, 1960, were reported at 525,000 cars, compared with 375,000 in November, 1959. Current stocks are indicated at close to 1,000,000 units.

Δ Inland Steel Co. concluded an agreement with the USW which will prevent a 25 per cent reduction in supplementary unemployment benefits to the company's laid off workers. Inland said it will keep full benefit checks using funds built up in periods when layoffs were small.

Δ The Bureau of the Census reports that shipments of nonferrous castings in September, 1960, totaled 179,919,000 lb compared with 171,428,000 lb in August, 1960.

December 7

Δ Government estimates placed business spending for new plant and equipment in the fourth quarter of 1960 at a seasonally adjusted rate of $35,600,000,000 down from the $35,900,000,000 in the third quarter and $36,300,000,000 in the second quarter of 1960. For the first quarter of 1961, a decline to a rate of $34,900,000,000 is foreseen.

Δ The Bureau of the Census reports that shipments of iron and steel castings in September, 1960, totaled 1,067,843 tons compared with 1,018,997 tons in August, 1960, and 1,025,175 tons in September, 1959.

December 8

Δ The Bureau of Statistics reported that steel output in Canada in November, 1960, totaled 436,699 tons compared with 532,499 tons in November, 1959; production of pig iron in November totaled 334,105 tons compared with 353,102 tons in November, 1959.

December 9

Δ The commerce Dept. reported that U. S. exports in 1960 may exceed imports by as much as $4,600,000,000. The department reported that imports are running at a seasonally adjusted rate of $14,900,000,000, compared with $15,200,000,000 in 1959; commercial exports are setting a yearly pace of $19,500,000,000 compared with $16,300,000,000 in 1959.

Δ A. S. Glossbrenner, president of The Youngstown Sheet and Tube, Co. said the company is considering investing in steel-producing facilities in Europe.

Δ The Bureau of Mines reported that consumption of scrap in October, 1960, totaled 4,373,000 gross tons, compared with 4,148,550 tons in September, 1960; pig iron consumed in October, 1960, totaled 4,019,000 gross tons compared with 3,816,397 tons in September, 1960.

December 12

Δ The Commerce Dept. reported that retail sales in November, 1960, held at just under $18,600,000,000 even with October, 1960.

Δ The AISI reports that the operating rate of the steel industry for the week of December 12, is scheduled at 1,387,000 tons (48.7 per cent of capacity). This compares with 1,396,000 tons one week ago (49.0 per cent capacity) and 2,726,000 tons one year ago. Index of production for the week is 86.3.

Δ The Bureau of the Census reports that shipments of commercial steel forgings in October, 1960, totaled 97,034 net tons, compared with 94,047 tons in September, 1960, and 97,302 tons in October, 1959.

Δ The Dept. of Commerce reported that shipments of cast iron pressure pipe and fittings in 1961 are expected to approximate 1,320,000 tons, compared with an estimated tonnage for 1960 of 1,307,000 tons and shipments of 1,441,000 tons in 1959.

December 13

Δ The Labor Dept. reported that unemployment at the month ended November 15, totaled 4,031,000, an increase of 450,000. Total employment in mid-November totaled 67,200,000, down 300,000 from October.

December 14

Δ Prices on lead and zinc declined. Zinc was trimmed to 12½¢ a lb, down ½¢; lead is 11¢ a lb, down 1¢.

December 15

Δ The AISI announced that it would discontinue reporting the steel industry weekly figures on operations expressed as a percentage of capacity early in 1961. Starting the first week in 1961 the AISI will issue weekly releases on steel tonnage produced for the week before, giving the percentage gain or loss from week to week.

Δ Crucible Steel Co. of America announced it had formed a new company, Crucible Steel Australia Pty., Ltd., as part of Crucible's wholly owned subsidiary, World Crucible, Ltd., to build a warehouse in Bankstown (an industrial suburb of Sydney) and distribute the full line of steels turned out by Crucible in the U. S. and Canada.

△ The AISI announced that steel production in November, 1960, totaled 6,167,000 net tons of ingots and steel for castings, down from 6,868,380 tons in October, 1960, and 7,267,607 tons in November, 1959.
△ The American Iron Ore Assn. reports that there were no shipments of iron ore down the Great Lakes in December, 1960; in December, 1959, the total shipments were 3,175,949 gross tons. Total final shipments for the season were 69,631,789 gross tons.

December 16

△ The Commerce Dept. reported that personal income in November, 1960, ran at a seasonally adjusted annual rate of $409,500,000,000, unchanged from the October level.
△ The Japan Iron and Steel Federation reports that production of pig iron in October, 1960, amounted to 1,198,000 net tons; in November, 1960, the total was 1,206,000 net tons; production of ingot steel was 2,174,000 and 2,200,000 net tons in October and November, 1960, respectively.

December 19

△ Government figures showed that private housing starts in November, 1960, ran at a seasonally adjusted annual rate of 1,235,000 units, one per cent below the October, 1960, level, and nine per cent under the November, 1959, pace.
△ The AISI reports that the operating rate of the steel industry for the week of December 19, is scheduled at 1,335,000 tons (46.9 per cent of capacity). This compares with 1,387,000 tons one week ago (48.7 per cent capacity) and 2,641,000 tons one year ago. Index of production for the week is 83.1.

December 20

△ Price of zinc in East St. Louis declined ½¢ to 12¢ per lb.

December 21

△ The Commerce Dept. predicted that 1961 auto production would decrease to 5,800,000 units, down almost 14 per cent from 1960's 6,700,000.
△ The ARCI reported that deliveries of new freight cars in November, 1960, totaled 3799 compared with 4632 in October, 1960, and 2218 in November, 1959. Orders in November, 1960, totaled 3680 compared with 5885 for October, 1960, and 2424 in November, 1959. Backlog of cars on order as of December 1, 1960 totaled 22,781 compared with 22,900 on November 1, 1960, and 36,555 on December 1, 1959.
△ The Bureau of the Census reported that net shipments of aluminum pig and ingot in October, 1960, totaled 123,403,000 lb compared with 105,622,000 lb in September, 1960, and 127,209,000 lb in October, 1959. Net shipments of aluminum mill products in October, 1960, totaled 246,887,000 lb compared with 253,263,000 lb in September, 1960, and 287,167,000 lb in October, 1959.
△ The AISC reports that shipments of fabricated structural steel in November, 1960, totaled 288,685 tons compared with 313,623 tons in October, 1960, and 180,772 tons in November, 1959. Bookings in November, 1960, amounted to 240,347 tons compared with 219,803 tons in October, 1960, and 260,190 tons in November, 1959. Backlog as of November 30, 1960, amounted to 2,016,062 tons.
△ The Aluminum Assn. reports that net shipments of aluminum sheet and plate in October, 1960, totaled 104,148,000 lb compared with 108,429,000 lb in September, 1960. Shipments of aluminum foil in October, 1960, totaled 20,904,635 lb compared with 20,389,007 lb in September, 1960.
△ The Aluminum Assn. reported that production of primary aluminum in the United States in November, 1960, totaled 161,208 short tons compared with 167,015 tons in October, 1960, and 153,666 tons in November, 1959.

December 22

△ Electric power used throughout the U. S. in the week ended December 17 totaled 15,000,000,000 kwhr, a new record.
△ The Commerce Dept. placed the U. S. Foreign-aid program at a cost of $4,200,000,000 for the fiscal year ended June 30, 1960, compared with $5,000,000,000 for the previous year 1958–1959.
△ M. J. Zivian, president, Detroit Steel Corp., announced the company called for redemption on December 30, 1960, the outstanding balance of 15,000 shares of the corporation's six per cent cumulative preferred stock, ($100 par value). The stock is held by Detroit Steel Corp.'s Retirement Income Fund.

December 23

△ The Bureau of the Census reported that shipments of nonferrous castings in the U. S. in October, 1960, totaled 183,536,000 lb compared with 179,944,000 lb in September, 1960.
△ The Bureau of the Census reported that production of titanium mill products in the U. S. in October, 1960, totaled 1,075,978 lb compared with 944,553 lb in September, 1960, and 358,513 lb in October, 1959.

December 26

△ The AISI reports that the operating rate of the steel industry for the week of December 26, is scheduled at 1,122,000 tons (39.4 per cent of capacity). This compares with 1,325,000 tons one week ago (46.5 per cent capacity) and 2,726,000 tons one year ago. Index of production for the week is 69.8.

December 27

△ The Labor Dept. reported that living costs in November rose 0.1 per cent to a record 127.4 per cent of the 1947–49 average.

December 28

△ The National Machine Tool Builders Assn. reports that new orders for metal cutting and forming machine tools in November, 1960, totaled $49,650,000; shipments totaled $48,050,000; compared with orders totaling $56,200,000 and shipments totaling $51,350,000 in October, 1960.
△ F. W. Dodge Corp. reports that construction contracts in November, 1960, totaled $2,886,131,000. The seasonally adjusted Dodge Index of construction contracts (1947–49 = 100) stood at 280 in November, compared with 294 in October and 271 in September, 1960.
△ Price of No. 1 industrial bundle steel scrap advanced about $5 to $34.70 a ton at Pittsburgh.

December 29

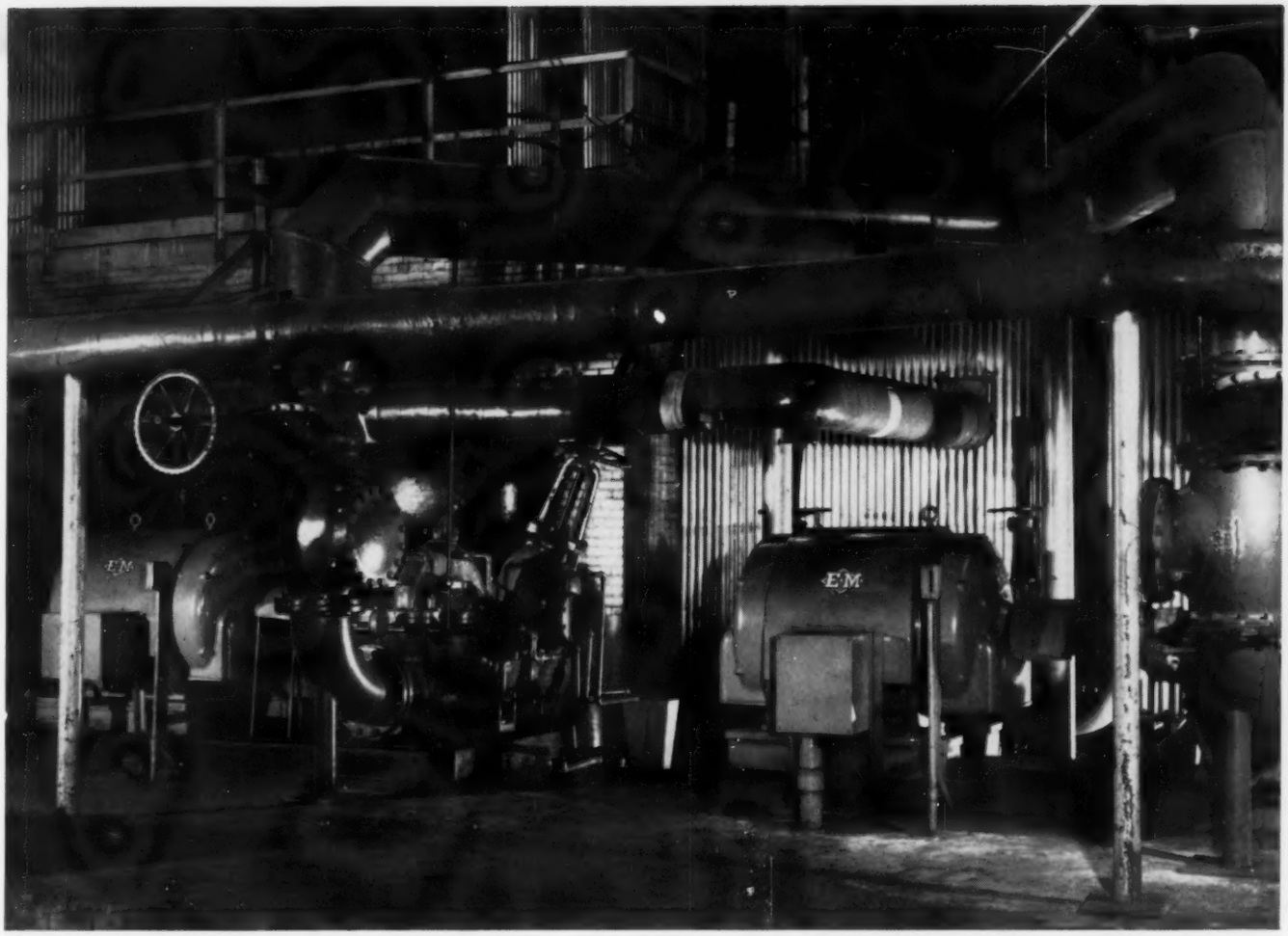
△ The Census Bureau reported that the value of construction work put in place in 1960 totaled $55,000,000,000 compared with $56,200,000,000 in 1959.

December 30

△ Treasury gold stocks now total $17,800,000,000 down $88,000,000 in the week ended December 28.
△ The Edison Electric Institute reported that electricity use in the week ended December 24 topped 15,100,000,000 kwhr, an increase of 93,000,000 kwhr over the previous week.

December 31

△ The Aluminum Assn. estimates that aluminum production in 1960 will be over 2,000,000 short tons, three per cent over 1959 production.
△ The Commerce Dept. estimated that U. S. exports in November, 1960, topped $1,700,000,000.
△ The United Mine Workers cut pensions for retired members from $100 a month to $75.



Jones & Laughlin Steel Corporation enjoys low maintenance costs on large motor drives

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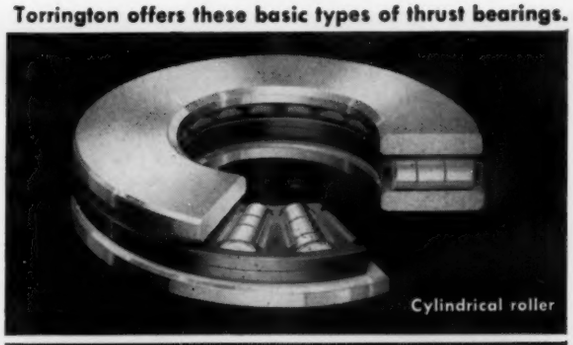

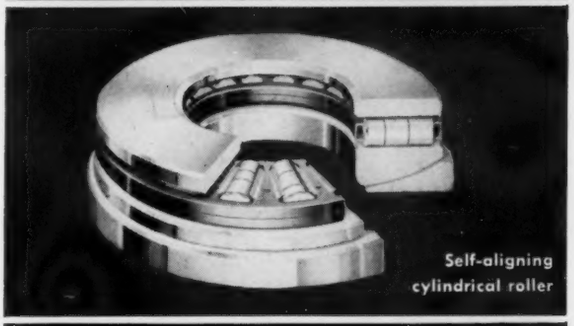

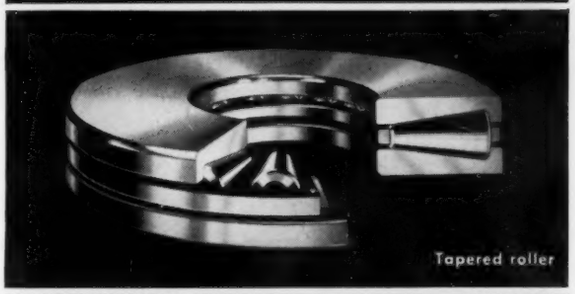

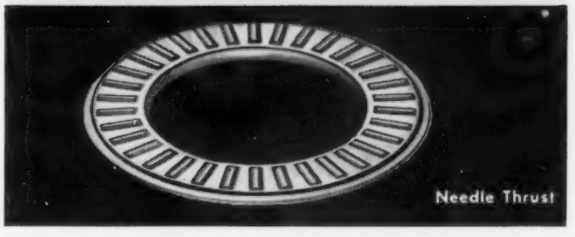

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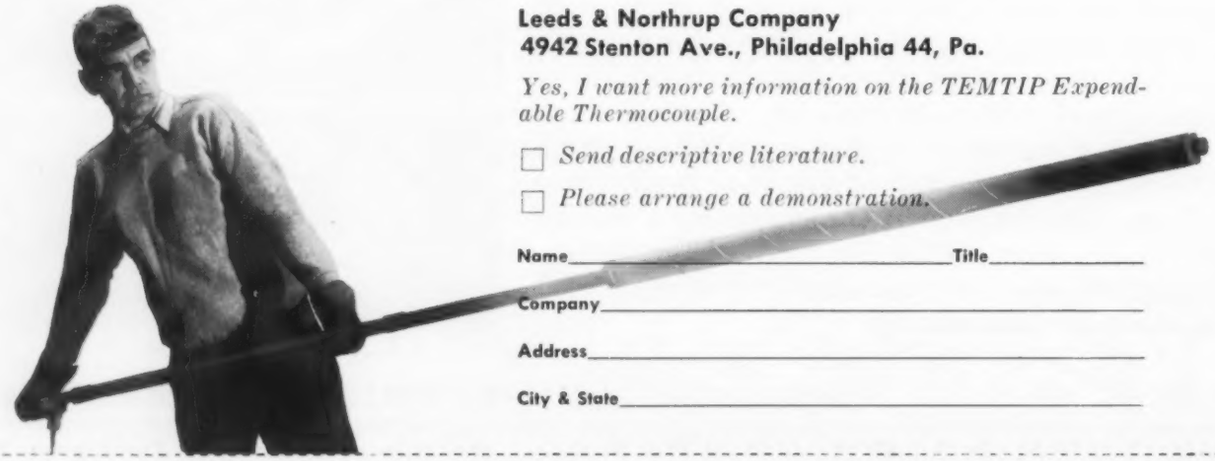

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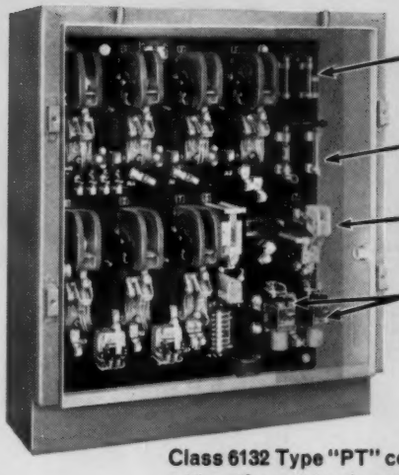

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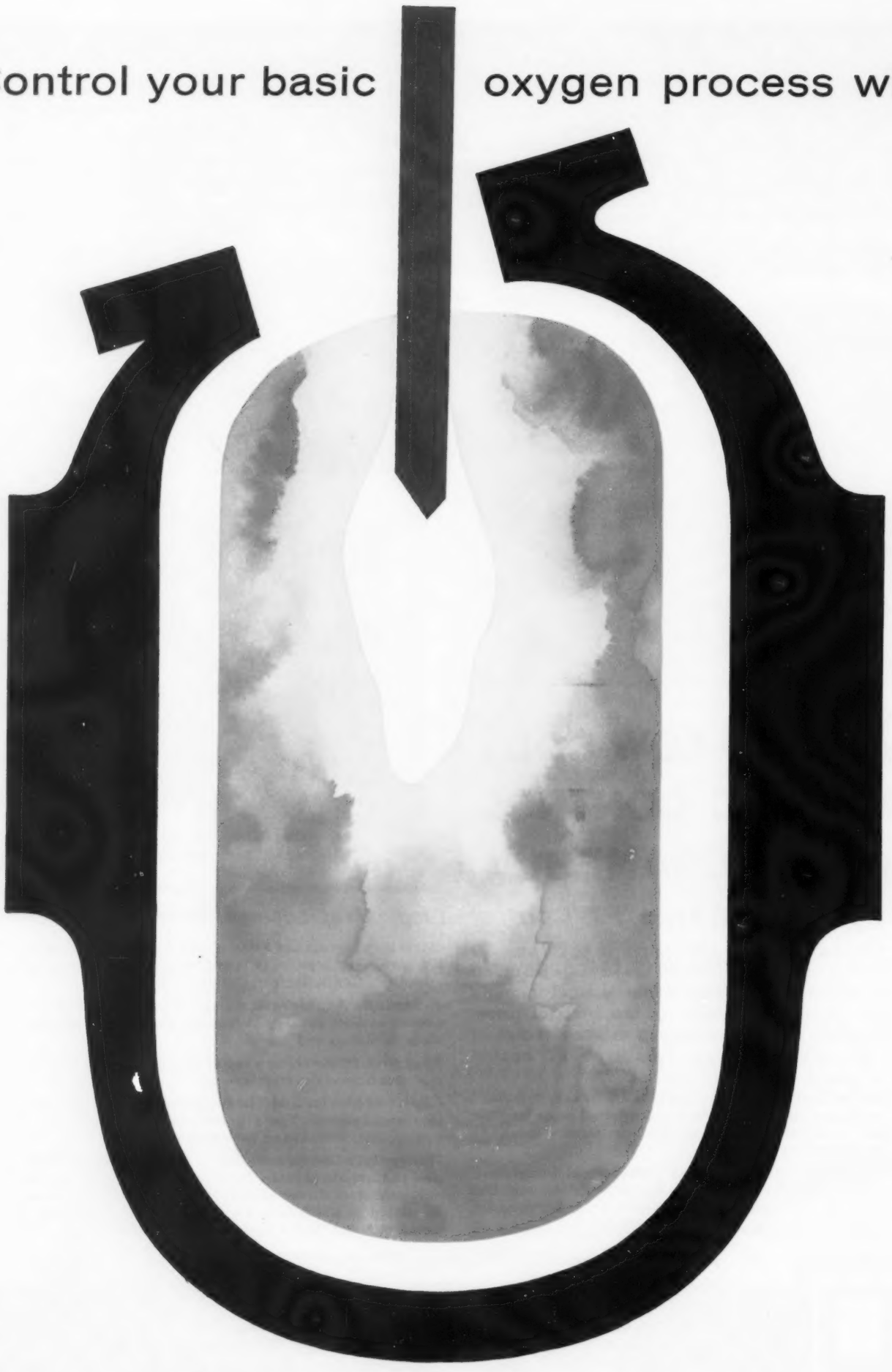

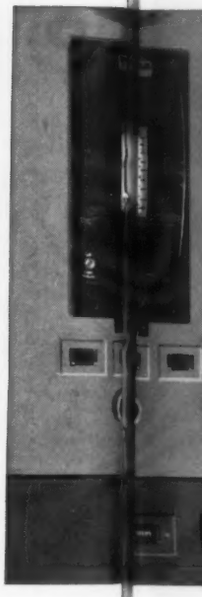

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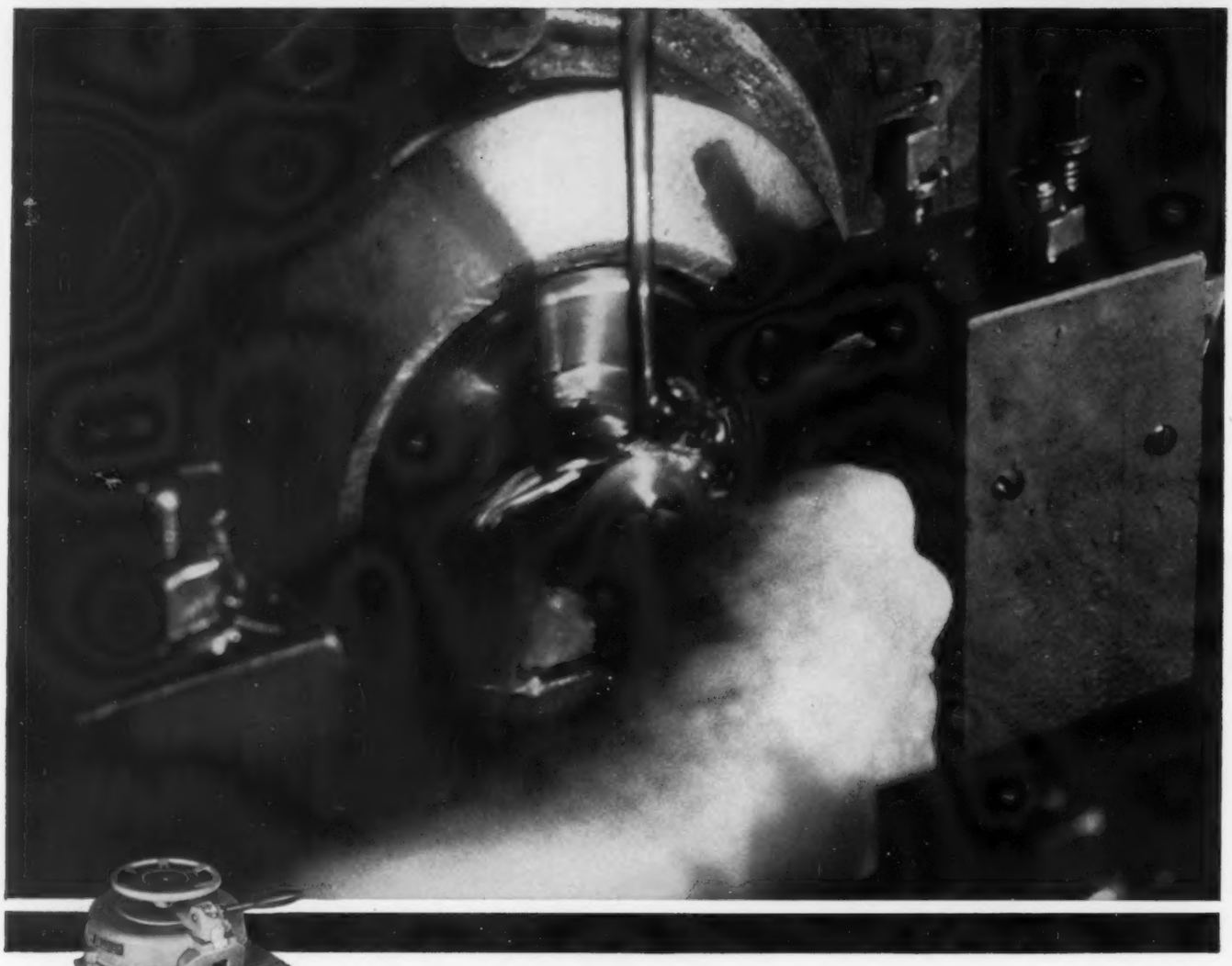


COOL CUTS

Keeping close tolerances is of prime importance at Diagraph-Bradley Industries, Inc., of Herrin, Illinois, leading manufacturer of stencil machines and accessories. One of the ways this is accomplished is by keeping cutting edges cool.

At Diagraph-Bradley stencil punches must be cut and held within .0005 of an inch—a fine point of precision Diagraph-Bradley attributes to the cooling and lubricating effect of Cities Service Chillo 10 cutting oil.

"You have only to take a Diagraph-Bradley machine," says one of the company officials, "cut a stencil with it and look at the resulting letter to realize how important the right cutting oil is to our production."

Cities Service Chillo 10 oil is a sulphochlorinated oil. The concentrations of sulphur and chlorine are stabilized by a special process, assuring uniformity of action through the entire cutting operation.

That's why, with Cities Service Chillo 10 cutting oil, work is always more accurate, clean and cool!

For full information call your nearest Cities Service office or write Cities Service Oil Company, Sixty Wall Tower, N.Y. 5, N.Y.

CITIES SERVICE

QUALITY PETROLEUM PRODUCTS

VICTOR R. BROWNING

Mill Type Cranes

TO SPECIFICATION...

Basically designed as required by A.I.S.E. specifications, mill type cranes built by Victor R. Browning & Co., Inc. also offer the opportunity of specifying preferences and standards prevailing in the purchaser's plant. May we have your next inquiry?

VICTOR R. BROWNING & COMPANY, Inc.

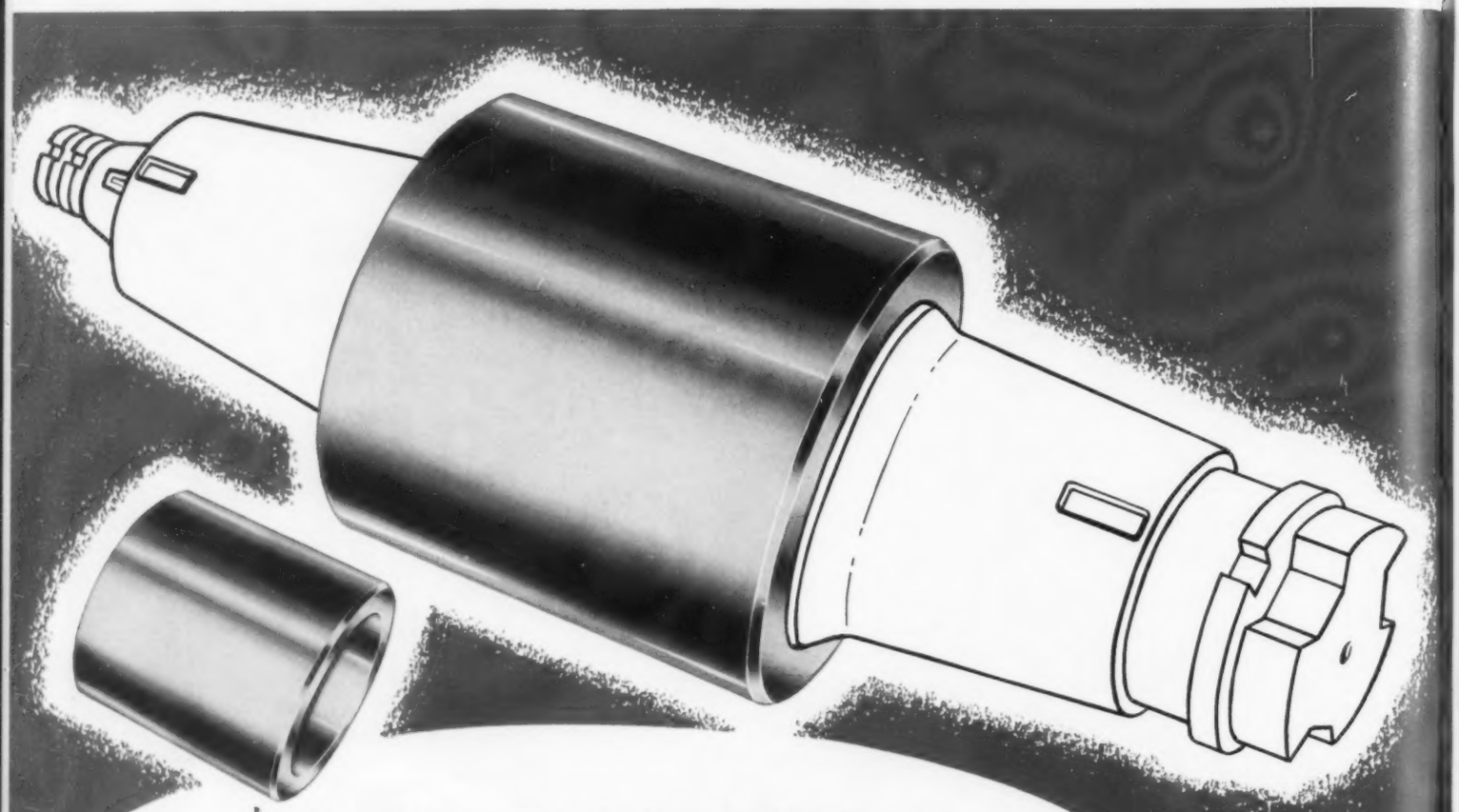
WILLOUGHBY (CLEVELAND), OHIO

DESIGNERS AND BUILDERS OF ELECTRIC OVERHEAD TRAVELING CRANES AND HOISTS AND ELECTRIC REVOLVING CRANES

Ohio

FORGED SLEEVES

and Cast Steel or Forged Steel Arbors for Back-Up Rolls



A Complete Back-Up Roll Service

Ohio Steel—specialists in manufacturing all types of iron, steel and forged steel rolls—now offers the rolling mill industry *a superior forged steel sleeve for back-up rolls.*

Ohio back-up roll body sleeves are forged and hardened from *balanced alloy vacuum poured degassed steel.* These sleeves are accurately machined and applied to either new or used forged steel or cast steel arbors.

Yes, Ohio Steel offers a complete back-up roll service. Ask your Ohio roll sales engineer about this modern facility that can help increase rolling mill efficiency.

THE OHIO STEEL FOUNDRY COMPANY
LIMA, OHIO

OHIO IRON and STEEL ROLLS

Carbon Steel Rolls	Flintuff Rolls	Denso Iron Rolls
Ohioloy Rolls	Double-Pour Rolls	Nickel Grain Rolls
Ohioloy "K" Rolls	Chilled Iron Rolls	Special Iron Rolls
Nioloy Rolls	Forged Steel Rolls	

PLANTS AT LIMA AND SPRINGFIELD, OHIO. *. Virtually at the center of the Steel Industry*

OR-45

Industry News...

NEW STRUCTURAL STEEL DEVELOPED IN CANADA

Δ Stronger, easier to use and more economical structural steel has been developed through the combined efforts of the Canadian basic steel industry, major Canadian fabricators and allied groups. In some structures it could reduce the weight of steel by as much as 12 per cent.

Announcement that the new grade of steel has had official specification approval by the Canadian Standards Association was made recently by C. C. Weeks, vice president—sales, The Algoma Steel Corp., Ltd. At the same time, he disclosed that Algoma Steel has already produced the new grade and will now proceed with it in regular production.

Algoma made important contributions to the development of this new steel. It will now produce plates, bars and structural shapes to this new specification.

Known as CSA-G40.8, the new grade is an entirely Canadian technological achievement that is expected to gain wide recognition in the structural field.

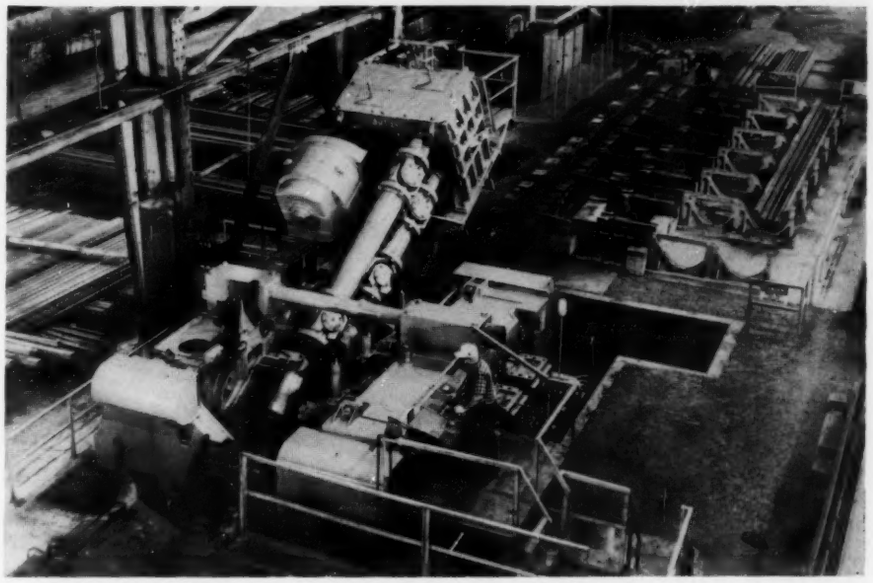
At a small extra cost, this steel is claimed to be stronger, tougher and easier to fabricate than other structural grades such as CSA-G40.4 (ASTM-A7) or the recent American ASTM-A36 specification.

Compared with a yield strength of 33,000 psi for G40.4 (the old specification) ASTM-A7 and 36,000 psi for A36 (the recently released ASTM specification), this new Canadian grade of structural steel has a guaranteed minimum yield strength of 40,000 psi for thicknesses up to $\frac{5}{8}$ in.

The new grade of steel was originally developed to combat brittle failure in steel structures, and shows improved toughness at low temperatures.

The properties of this new structural grade are obtained particularly by the metallurgical control of chemistry and of physical properties, rather than by types of furnace processes.

GIANT BAR STRAIGHTENER OPERATING AT SHEFFIELD



This heavy-duty Sutton Engineering Co. 5BC straightener is installed at the Sheffield Steel Division of Armco Steel Corp. at Houston, Texas, for precision straightening of alloy, heat-treated hot rolled bars from 3 in. to 9 in. diam. for oil country drill collar stock.

LORAIN OPERATING NEW BUTTWELD PIPE MILL

Δ A modern continuous weld pipe mill went into production last month at Lorain Works of United States Steel Corp.'s National Tube Division. Complete with revolutionary operating features and innovations in production and quality control the new mill has finished its shake-down trials and crew-training period and will now produce buttweld pipe for customer use.

Over two and a half years under construction, the new mill will produce pipe in diameters ranging from $1\frac{1}{4}$ in. to 4 in. Capacity of the new mill will be 237,000 tons of pipe annually.

The buttweld pipe producing process in the new installation is completely continuous as coil after coil of skelp is flash welded end to end and fed through the mill. The steady flow of steel passes through a preheating chamber which utilizes waste gases of the heating furnace. Then it is brought up to the proper predetermined temperature as it passes through the various zone levels in the long main furnace. As the continuously moving strip of steel, now red hot, emerges from the heating furnace the skelp is immediately formed into a 270 deg arc by passing through the first forming rolls, then moves on into the welding rolls which bring the two edges completely together and fuses them into a smoothly perfect and continuous weld.

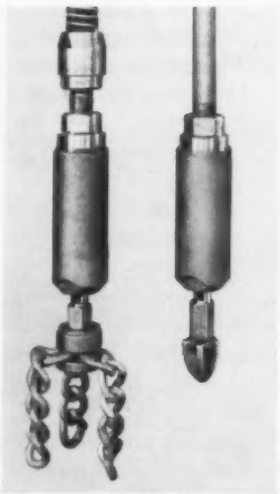
Thus the flow of steel now continues in the form of pipe instead of flat skelp. The pipe moves next into a stretch reduction mill. The stretch reduction mill utilizes a new principle in roll positioning that will allow almost instantaneous roll adjustments to be made so that pipe size can be varied while the mill is in operation. Constant speed ratios between the various stands of the stretch reduction mill are maintained by a system of hydraulic differential drives marking the first time such a system has been used in the steel industry.

The still moving pipe, is next cut to length by a flying saw that is

CHECKERWORK cleaned faster, better with

ELLIOTT TUBE CLEANER

Substantial saving of time and labor, and thorough cleaning of passages without harm to brickwork are effected through the use of standard Elliott tube cleaner air motor with the special whirling chain head illustrated at the right. If stubborn deposits require drilling, the same motor can be equipped with an extension piece and drill. The photographs above show how effectively square corners are cleaned. Many steel mills report savings in manhours as high as 50 percent with use of the Elliott checkerwork cleaners. Write for complete details.



Motor with chain head (left) and with drill and extension piece

ELLIOTT Company
Lagonda Plant • Springfield, Ohio

YO-1

synchronized to the speed of the mill and the pipe is conveyed to the three stand sizing mill for the final sizing operation. The pipe lengths then continue moving via conveyor to the cooling beds.

The pipe is then ready for finishing operations which include cutting to the proper length and precision straightening as well as facing and a series of inspections including hydrostatic testing.

According to customer requirements, pipe from the new mill may be black or galvanized, plain end, threaded and coupled or threaded only.

KOPPERS TO REBUILD WHEELING COKE OVENS

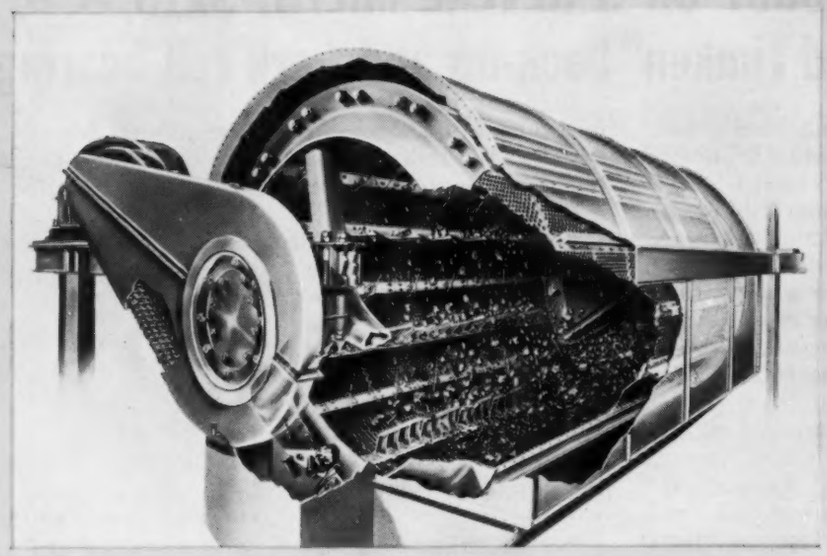
△ The Engineering and Construction Division of Koppers Co., Inc. has received authorization from Wheeling Steel Corp. to rebuild a battery of 51 coke ovens at its East Steubenville, W. Va., plant. This plant has six coke oven batteries with a total of 314 ovens.

The existing No. 3 Battery of 51 ovens, built in 1926, will be torn down and the new ovens constructed on the old foundation. The new battery is expected to be completed in 1961.

TO MOVE ADMINISTRATIVE OFFICES TO PITTSBURGH

△ The E. W. Bliss Co. announced plans to move its corporate administrative offices from Canton, Ohio, to Pittsburgh, Pa., where they will be located in the Number 4 Gateway Center Building. The move will be made early in March. It will not affect operations at the company's plant in Canton.

The administrative offices' relocation has been influenced by a number of considerations, according to J. R. Patterson, president, but two principal factors predominated. "First," he said, "it is our belief that the interests of efficiency are best served when the corporate management of a company like Bliss is physically separated from the management of each of its individual divisions. Second, Pittsburgh is the location of the home offices of a number of firms with which Bliss does much business, and closer proximity to these customers will enable us to serve them better."



Pennsylvania Bradford crushes, sizes, scavenges all in one operation—at lowest cost

PENNSYLVANIA BRADFORD BREAKERS prepare over 160 million tons of coal each year

Because no other coal processing machine does so much for so little—Pennsylvania Bradford Breakers have become a standard of the industry.

At power plants, by-product coke plants, coal mines and coal cleaning plants Pennsylvania Bradfords clean, size and scavenge at phenomenal low cost.

Data from 10 installations over 8 years shows an average maintenance cost of $.001 per ton, and an average power consumption of .204 KW per ton.

TRIPLE ACTION

Continuously charged, the Pennsylvania Bradford immediately screens out passing sizes of coal through the screen plates. Larger lumps are raised and dropped, breaking by gravity impact until they are screened. All refuse—sulphur balls, slate, rock, tramp iron, etc.—resist breakage and travel the full length of the breaker where they are discharged.

BRADFORD-HAMMERMILLS

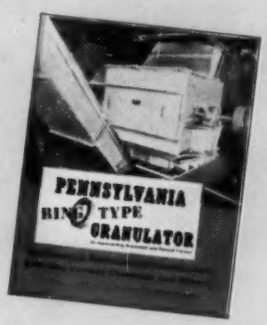
For reduction of particularly hard coals and for heavier loading, Bradford-Hammermills are frequently specified. This machine combines a concentrically-mounted rotor of a hard-hitting Pennsylvania Hammermill at the rear end of the slow speed Bradford Breaker. Capacities are increased over 20%.

FREE BULLETIN

For the full story on Pennsylvania Bradford Breakers and Bradford-Hammermills write for Bulletin 3007.

RING-TYPE GRANULATORS

For preparing coals for stoker and pulverizer fuel, and other uses where overgrinding is undesirable, Pennsylvania Ring-type Granulators have no peer. Exclusive design; exclusive advantages. Completely described in Bulletin 9002. Send for it.



PENNSYLVANIA CRUSHER DIVISION
BATH IRON WORKS CORPORATION
WEST CHESTER, PENNA.

★ ★ ★

Over 50 years concentrated experience in all types of material reduction makes Pennsylvania your best source of crushers and engineering advice and service. Call on Pennsylvania with your next crushing problem. Representatives from coast-to-coast.

PENNSYLVANIA CRUSHERS

BATH-BUILT

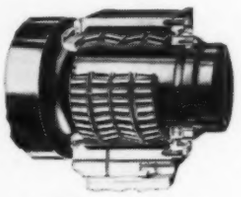
1 YEAR LUBE COST ON 3 REVERE MILLS: $115
with oil mist lubricated Timken® back-up and work roll bearings

You probably spent as much money lubricating your car last year as Revere Copper and Brass Incorporated spent on these three mills together. They used 3 barrels of oil in a year. All three of these aluminum mills are on Timken® tapered roller bearings, with standard tapered bore (TQIT) bearings on the back-up rolls. And furthermore, operators of the two rolling mills in the Revere plant at Chicago report that after three years of operation, the original grinding marks were still clearly visible in the load zones of the back-up roll bearings indicating no measurable wear.

In addition to the lubrication economies of oil mist systems on Timken bearing-equipped mills, Revere's experience proves that the "Balanced Proportion" design of Timken bearings, increases roll neck strength, increases mill rigidity and keeps the aluminum being rolled on gage.

Because Timken bearings lend themselves to oil mist lubrication, operators realize another big advantage. No seal leakage is experienced, thereby eliminating staining of rolled product and contamination of rolling solution.

If you're buying or building a rolling mill, be sure to get the latest information on roll neck and screw down bearings from the Timken Company. Our graduate engineer salesmen will work with you to help you get the most bearing capacity, the most bearing life for your bearing dollar. The Timken Roller Bearing Company, Canton 6, Ohio. Cable address: "TIMROSCO".

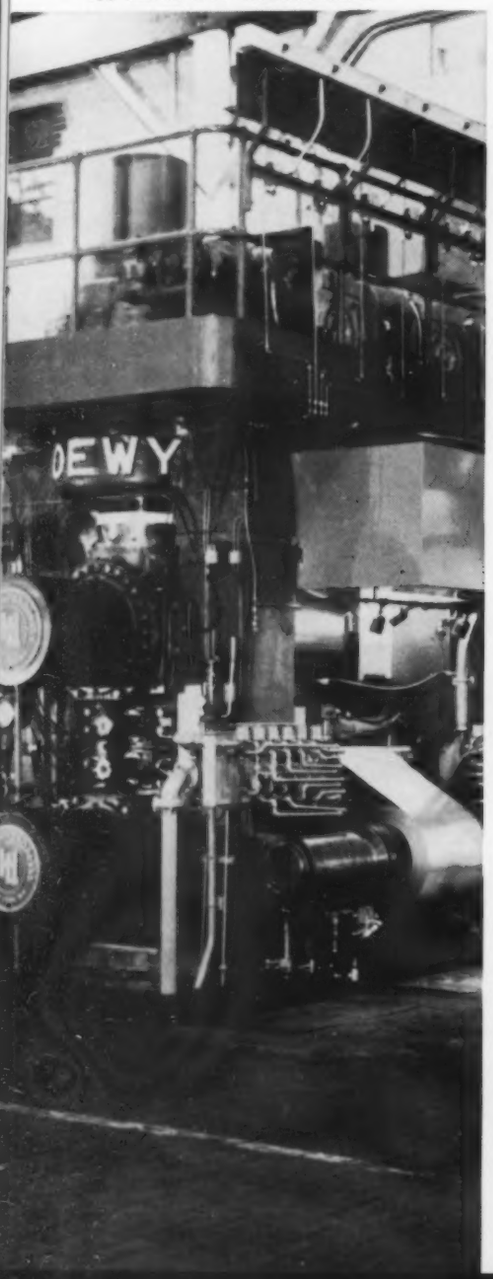


Industry rolls on

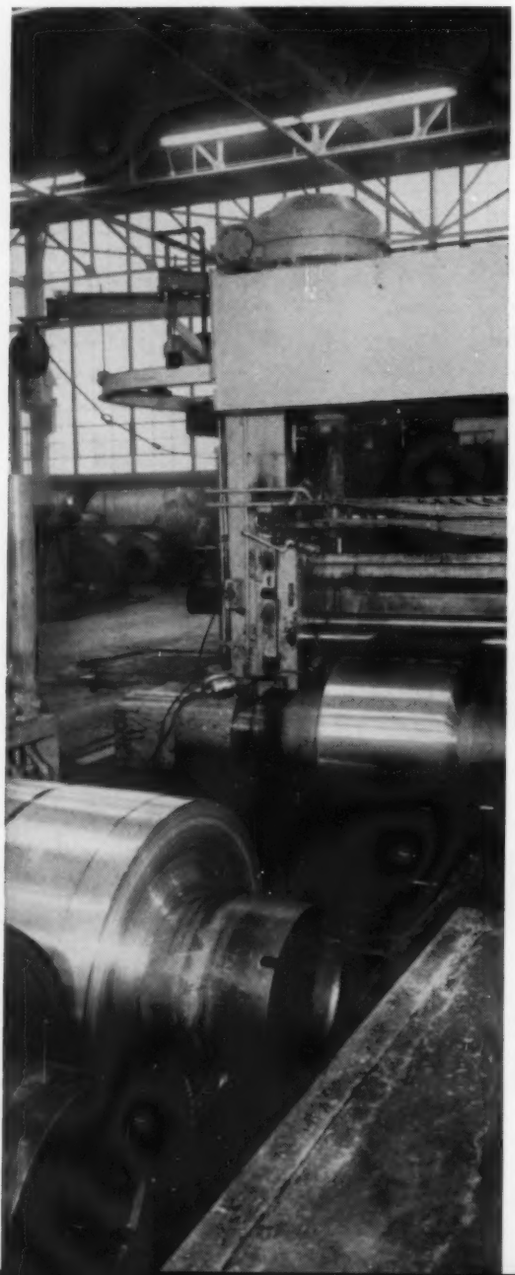
TIMKEN®

tapered roller bearings

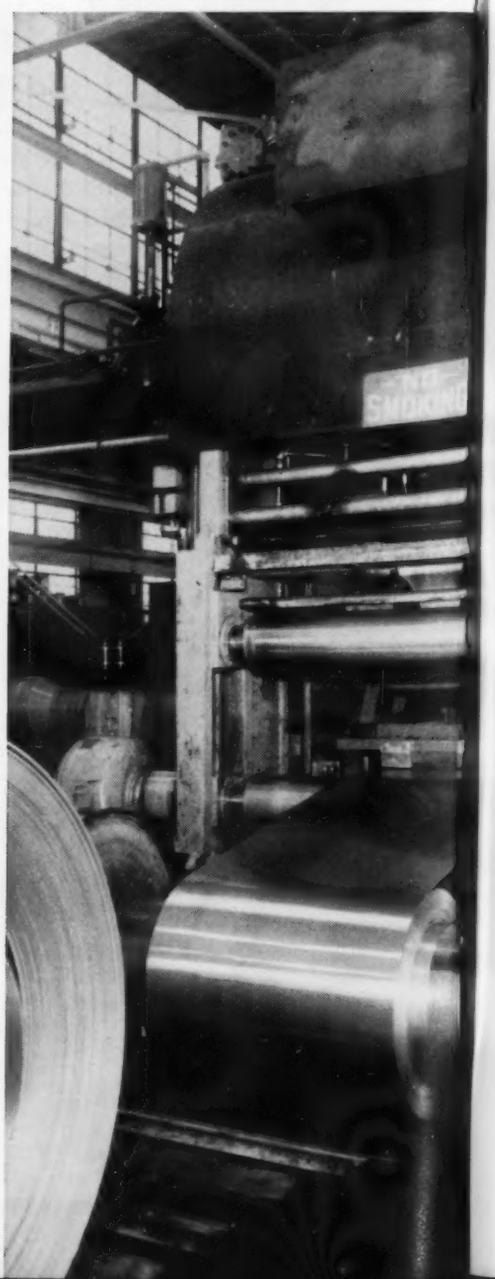
9½" AND 33" x 44" COLD FINISH MILL



12" AND 35" x 62" ALUMINUM FINISH MILL

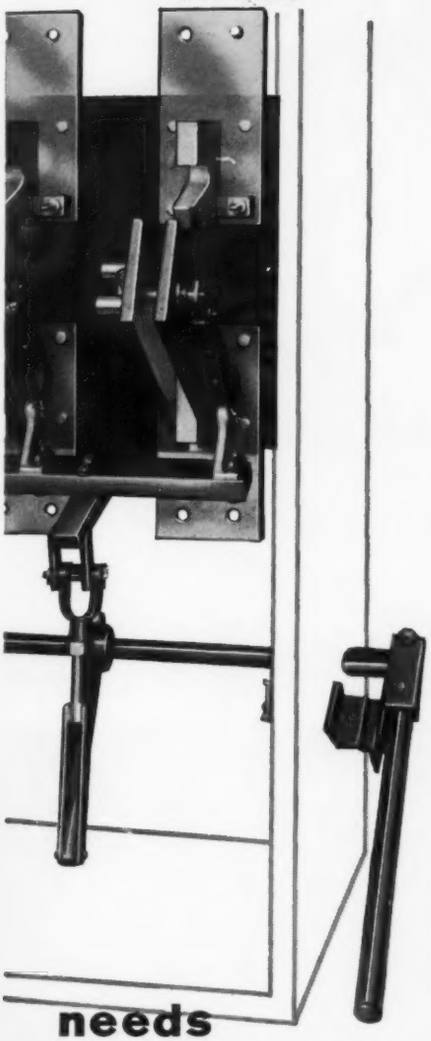


18" AND 45" x 62" ALUMINUM RUNDOWN MILL



RARELY

(IF EVER)



needs

MAINTENANCE

Pringle disconnect switches for high-current equipment carry as much as 50,000 amperes, continuously, with no more of a heat rise than you would get from copper bus bars bolted together. These switch blades actually are bolted together. Under a constant pressure of 600 lbs./sq. inch. Without springs. Yet, they open easily after months (or years) of closed operation. Heat, fatigue, lack of movement won't affect the operating mechanism. Constant, periodic maintenance is unnecessary.

Less complex than most high-capacity disconnect devices. Less expensive too. Available in single- or multi-pole models, front or rear connected, live front or steel enclosed. With or without high-capacity fuses. For use on crane conductor rails, transformer secondaries, or AC and DC switchboards. Wherever high-current equipment must be isolated for periodic servicing.

Write for Industrial Switch Catalog

PRINGLE

ELECTRICAL MANUFACTURING CO.

1904 NORTH SIXTH STREET
PHILADELPHIA 22, PENNA.

The company has manufacturing facilities in the United States, England, France, West Germany and Canada.

CRUCIBLE TO OPERATE AUSTRALIAN WAREHOUSE

Δ The Crucible Steel Co. of America, through its wholly owned subsidiary, World Crucible Limited, has established an Australian company, Crucible Steel Australia Pty. Limited. The new company will distribute the full line of specialty steel products of Crucible Steel of Canada Limited and the United States company.

As an initial step in the operation of the new company, land has been purchased in Bankstown, a suburb of Sydney, for the immediate construction of a warehouse. Crucible becomes the first North American specialty steel company to begin warehouse operations in Australia.

George S. Cox has been appointed manager of the new operation. Formerly technical manager of Crucible Steel International, S. A., Mr. Cox has had considerable experience in the industrial applications of specialty steel in Australia and Canada as well as in the United States.

SHEFFIELD ADDING NEW VERSATILE UNLOADER

Δ A multi-purpose, rope-operated traveling unloader, to be erected on a new dock facility at the Houston, Texas, works of the Sheffield Steel Division, Armco Steel Corp., is being designed and constructed by Dravo Corp.

In handling ore the machine will utilize an 11-ton-capacity bucket and will have a free-digging rate of 1000 tons an hour.

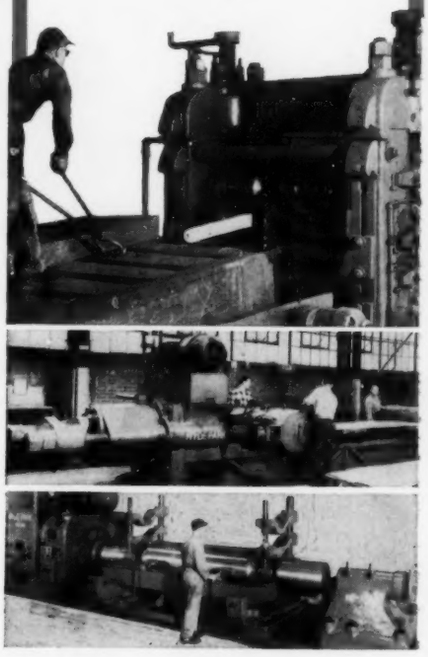
The unloader's shuttle trolley reeving system permits bucket changes in less than 30 min, enabling the operator to switch from ore to coal unloading with a minimum of delay.

The unloader will be part of an elaborate materials handling system on the 1000-ft-long dock, which is designed to accommodate the largest ocean-going ore carriers.

Ore will be transferred from a ship's hold to the unloader's 108-ton-capacity hopper, which is equipped with a rotating feeder so

Hyde Park

ROLLING MILL EQUIPMENT



Hyde Park Engineers are always ready to co-operate with you in selecting and applying the rolling mill equipment best suited to your operation.

Bar Mills • Merchant Mills
Sheet and Strip Mills
Stretcher Levellers
Roller Tables • Pinion Stands
Sheet Mill Shears
Roll Lathes • Reduction Drives
Special Machinery • Machine Work

Hyde Park

FOUNDRY AND MACHINE CO.

HYDE PARK
Westmoreland
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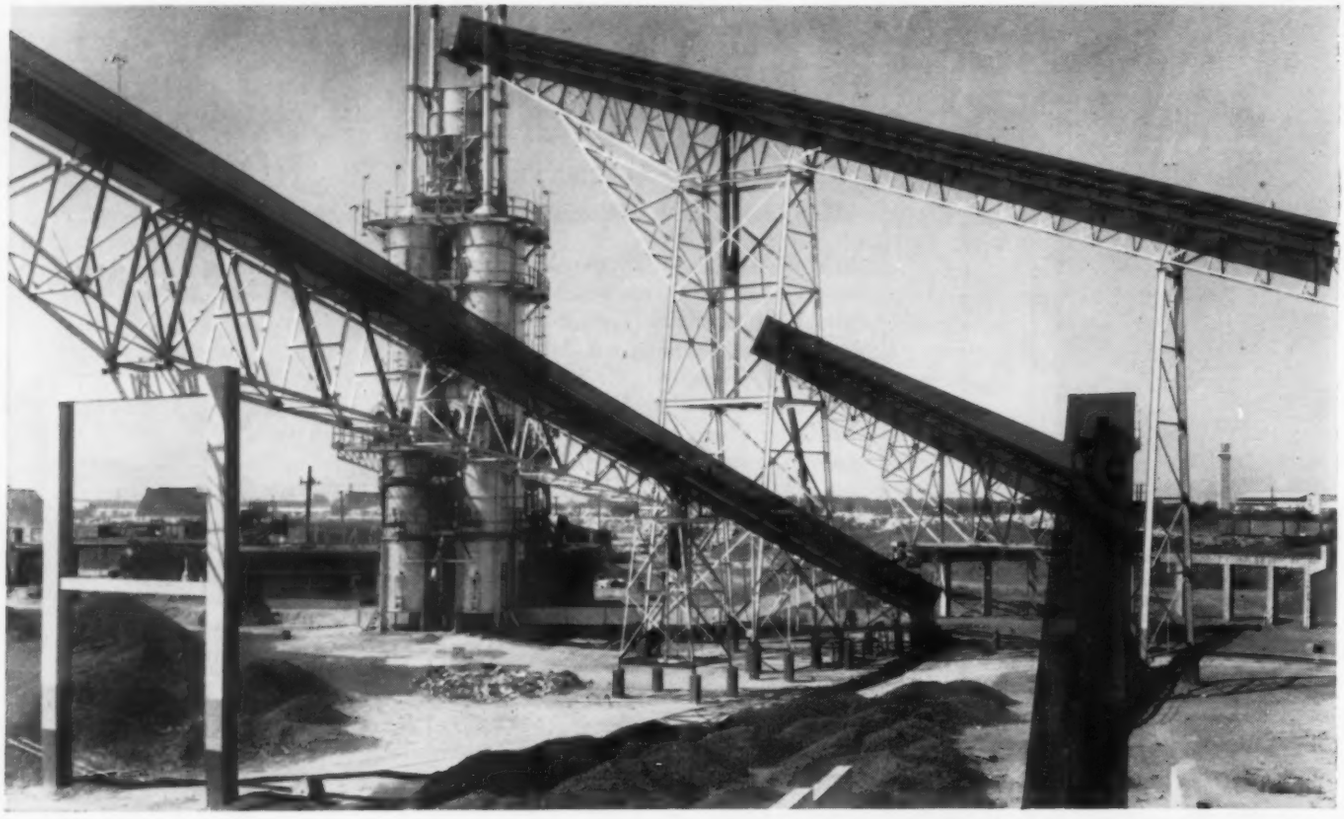
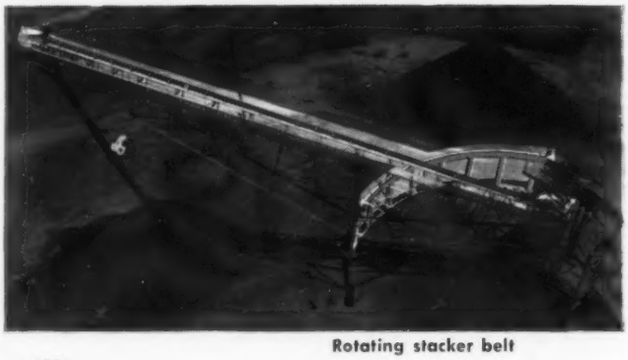
Rolls
Rolling Mill Equipment
Gray Iron Castings





Rotating stacker belt

PLANET SYSTEM CONVEYS, SORTS AND STORES 150 TONS OF IRON ORE PER HOUR . . .

another example of PV Planet Versatility . . .

Near Monterrey, Mexico, stands the maze of conveyors partially shown above. This system's job is to convey 150 tons of iron ore per hour through crushing operations to segregated storage areas, then reclaim it by grade. And it is one of many examples of PV—*Planet Versatility* . . . Planet Corporation's ability to find efficient solutions to production, materials handling or automation problems, big or small.

From a pit where the ore is crushed, a 24-inch trough-belt conveyor carries it to a secondary crusher. Here the rock is reduced and screened. Chunks larger than 1-inch diameter are recirculated, the fines are separated and transferred to a special stacker, and the usable ore is conveyed to a rotating stacker belt which piles it according to grade. To reclaim the ore, Planet constructed a series of tunnels under the storage area. The tunnels allow selection of the grade of ore to be conveyed to the retort in which sponge iron is made.

Let Planet demonstrate how its versatile engineering skill and production and erection know-how can solve your handling problems. Call or write . . . you'll find *it pays to plan with Planet.*

Sales Offices in Principal Cities in the United States and Mexico

PLANET CORPORATION

1816 SUNSET AVENUE • LANSING, MICHIGAN

- Engineered Handling Systems
- Automation Equipment
- Mill & Foundry Handling Equipment

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VALUED FOR
Economy

TM
alloy slings

Cut chain costs! Gain the economies of longer service and a better safety record with TM Alloy Slings. Taylor's sure-grip Tayco Hooks and complete heat-treating are strong contributing factors to this economy. Factory-assembled. Test Certificate furnished. Call your distributor, steel warehouse, hardware wholesaler or write for Bulletin 14A today.

S. G. TAYLOR CHAIN CO., Inc.
Plants: Hammond, Indiana
3505 Smallman St., Pittsburgh, Pa.

Prompt repairs on alloy slings in both plants.

Taylor Made CHAIN SINCE 1873

that ore can be directed either onto a belt conveyor leading to the mill's ore blending piles, or onto one of two rail tracks passing under the unloader tower.

The feeder also can divert ore onto a 1000-ton-an-hour inclined stacker belt, an integral part of the unloader, which discharges ore into a stockpile behind the dock. Center line of the stockpile will be 75 ft beyond the unloader's back travel rail.

From the stockpile, ore will be reclaimed by the unloader and discharged either onto the yard belt or into rail cars.

Coal, which arrives at Houston via the Mississippi River System and the Gulf Intracoastal Waterway, will be unloaded onto the yard belt, which will be reversed to transport the coal to coke ovens.

The operator's cab will be located on the unloader structure just under the boom. To assure optimum visibility for both ship unloading and reclaiming from the stockpile, the cab will be designed to shuttle between the front and back of the tower.

A second cab on the lower portion of the tower, between the two rail tracks, will be utilized for control of car loading operations.

Hoisting speed of the unloader will be 360 fpm, with the trolley rocking back and forth at 540 fpm. Because of the variation in distances the digging cycle will be 39 sec from ship to hopper, and 32 sec for reclaiming from stockpile to hopper. The unloader will travel along the dock at a speed of 75 fpm

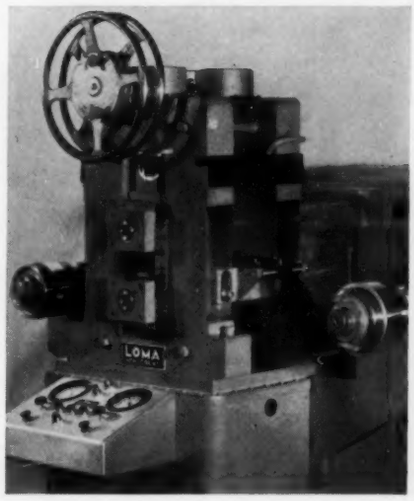
Of all-welded steel construction, the unloader will be driven by adjustable voltage d-c motors, operating from a 2300-volt, 3-phase, 60-cycle power supply.

Spring-set, hydraulically-operated Gale-Guard rail clamps will provide a safety factor against wind damage. The clamps will engage automatically when wind velocity reaches 35 mphr or if power fails.

BILLET CENTERING UNIT OPERATING AT SHELBY

△As a part of its mill expansion and equipment upgrading program for producing special quality tubing, Ohio Seamless Tube Division of Copperweld Steel Co. has recently placed in service a new precision

NEWS FROM
LOMA



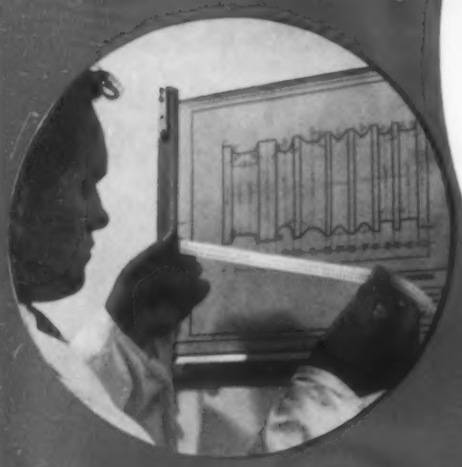
This rugged and versatile reversing 2-high / 4-high combination mill brings high-precision rolling of thin-gauge ferrous and non-ferrous strip within reach of the smaller re-rolling mill, metals pilot plant and research laboratory. Occupying only 35 sq. ft. of floor space and involving a cost of less than $20,000, the machine handles up to 6 in. wide strip at rolling speeds up to 250 ft. per min. with accurate front and back tension control.

The new 8 in. mill is furnished with two sizes of 4-high work rolls, made of either alloy tool steel or solid tungsten carbide: the 1½ in. size is used for normal cold reduction down to 0.002 in. thickness, and the ¾ in. size allows special ultra-thin finishing to gauges of less than 0.001 in. In the 4-high setup, the machine handles up to ⅛ in. gauge; the 2-high arrangement is used for the hot or cold breakdown of heavier materials up to 1 in. thick, but is also available for skin pass rolling of thin strip.

The production of close-tolerance stock is assured by an exceptionally rugged mill design, employing steel housings of 160 sq. in. post area, super-precision needle roller journal bearings of 175,000 lb. separating force capacity, a heavy-duty mill drive with herringbone gearing and universal joint spindles, and twin-handwheel worm drive screwdowns. The machine is powered by a four-speed reversing drive offering constant horsepower from 40 to 250 ft. per min. rolling speed.

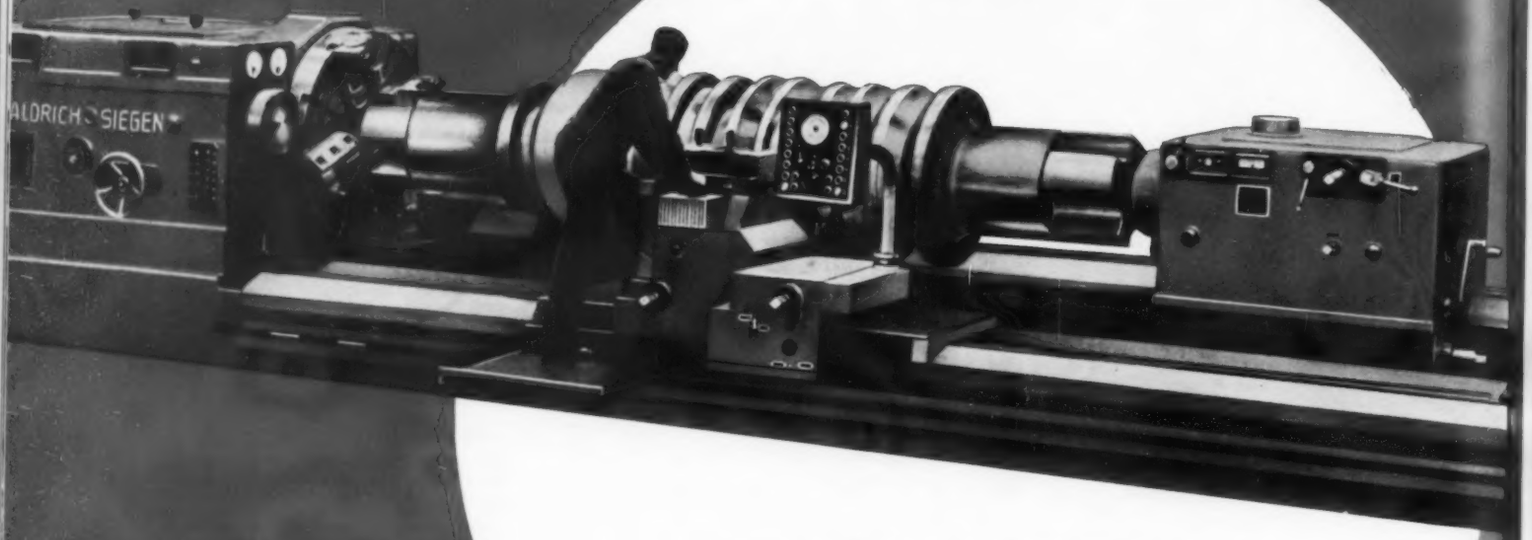
The outstanding feature of the new machine is its reversing strip coiling attachment allowing the two-way rolling of strip under tension control with no more effort than a mere flick of a selector switch. Mounted on brackets at either side of the mill, the two coiling shafts carry 8 in. diameter reels designed for a coil buildup of 6 in. Both shafts are driven from the pinion stand and are provided with dual air-operated slip clutches and brakes of ultra-sensitive, low-inertia design. Selective operation through solenoid valves and pressure regulators precisely controls the front and back tensions desired for any given mill pass.

LOMA
MACHINE MFG. CO., INC.
114 East 32nd Street
New York 16, N. Y.



NEW DEVELOPMENT
by WALDRICH SIEGEN

Outstanding West German Heavy Machine Tool Manufacturer



NUMERICALLY CONTROLLED ROLL GROOVING LATHE

No need for specially trained operators
No templates
Longer service life of rolls, as our positioning system computes automatically the most favorable position of grooves.

WALDRICH SIEGEN

H. A. WALDRICH G. M. B. H. SIEGEN · GERMANY

AMERICAN WALDRICH MFG. CORP. • 1232 Penn Avenue, Pittsburgh 22, Pa.

billet centering machine at its Shelby, Ohio, plant.

Accurate location of the billet centering hole, prior to the critical tube piercing operation, greatly improves concentricity and dimensional accuracy of the pierced tube and also reduces rejects, according to the Ohio Seamless Tube Engineering Department.

Other advantages of the new centering device, over equipment previously used, include sharp reduction in shell crop loss because of the greater concentricity of the starting end. Another plus feature is the increase in center hole depth that facilitates piercing of the tube round. The equipment can handle steel tube rounds from 3 to 7 in. OD, at a rate of 5 per minute. Minimum billet length is 22; maximum length is 10 ft, with weight of billet up to approximately 1100 lb.

According to the announcement, the new billet centering machine is unique in that only the actual work-end of the tube round is gripped while the hole is being formed, and also because billet length and diameter are of no consequence. Immediately after the billet is automatically positioned between the gripping jaws, a dual purpose hydraulic cylinder closes the jaws with a force of nearly 190 tons and moves the centering tool into the center of the billet with a 70-ton force. The centering tool and gripping jaws then retract and the billet is ejected.

METAL & THERMIT CORP. FORMS SWISS SUBSIDIARY

△ Metal & Thermit Corp. has formed a wholly owned subsidiary in Zug, Switzerland, to increase its participation in the growing European market, it was announced by H. E. Martin, president.

The new subsidiary, Metal & Thermit AG, will act as the parent company's sales and licensing representative in Europe. It will also license its own patents and trademarks.

Meetings

△ Some 400 technical, economic and education papers will be presented at the 90th Annual Meeting of the American Institute of Mining, Metallurgical, and Petroleum Engineers, February 26—March 2, 1961, in Chase Park Plaza and Ambassador Hotels, St. Louis, Mo.

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tells you the temperature!
NEW Markal®
THERMOMELT
TEMPERATURE INDICATORS
A STIK FOR EVERY TEMPERATURE FROM 113°F TO 2000°F
JUST MARK OR STROKE ANY SURFACE TO BE HEATED . . .
with a handy MARKAL THERMOMELT Stik. When the mark melts, your temperature has been reached. Choice of 65 exact (plus-minus 1%) temperatures from 113° F. to 2000° F. THERMOMELT's also available in Liquid and Pellet for difficult or hard-to-measure spots . . . same wide range of temperatures. Make sure you're always right on the button . . . make sure you use MARKAL THERMOMELT for precision temperature indicating.
EASY-TO-USE ADJUSTABLE METAL HOLDER AND DISPENSER
THERMOMELT
SEND FOR new Markal Thermomelt brochure and free sample pellets. Please state temperature requirements
Available at your Welding and Industrial Distributor
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GENERAL REFRACTORIES

imperishable records...

BRANDS FOR THE HOT BLAST STOVE

OLIVE HILL STOVE—Like OLIVE HILL BF for Blast Furnaces, OLIVE HILL STOVE is a highly accredited brand of high duty fireclay brick for hot-blast stoves, well known throughout the world.

HIAC-K STOVE—This superduty fireclay brick is widely used in well walls, domes and top checkers of hot-blast stoves that must endure severe operating conditions.

SUPERAC-K STOVE—High-fired superduty fireclay brick with their greater strength and volume stability are needed for the hotter sections of many stoves in high temperature operation. SUPERAC-K STOVE are outstanding in meeting this need.

HI-SIL STOVE—The most recent addition to the galaxy of GREFCO brands describes a semi-silica brick with extreme hot-load strength and spalling resistance. This brick is ideal for many hot-blast stove lining and checker applications.

...in brick

The most imperishable records in brick have survived *6000* years. The brick illustrated, for example, was used for making records at the Ur of the Chaldees, the City of Abraham.

The next best record in brick has been made by GREFCO linings. These brick were used for making *production* records.

GREFCO is proud of the many production records made on its Blast Furnace and Hot Blast Stove linings. GREFCO has specialized in the production of high quality brick for blast furnace linings and for hot blast stove walls, domes, rectangular checkers and multihole checkers. GREFCO's production facilities have been greatly increased and kept thoroughly modern in step with new technological developments.

GENERAL REFRACTORIES COMPANY

1520 Locust Street, Philadelphia, Pa.

BRANDS FOR THE BLAST FURNACE

OLIVE HILL BF—This brick is known throughout the world as an exceptional high duty fireclay brick for blast furnace linings.

OLIVE HILL HI FIRED—This blast furnace brick is made from the same materials as OLIVE HILL BF but is fired to higher temperatures to provide greater density, strength and better resistance to carbon disintegration.

SUPERAC-K-BF—This blast furnace brick is made from more superduty quality refractory clays, hard fired to develop increased density, resistance to spalling, and resistance to carbon disintegration. These brick can be used in zoned linings in combination with other blast furnace brands or can be used throughout the lining.

SUPERAC-K-BF (SR)—is a variety of SUPERAC-K-BF, that is formulated and processed to provide maximum slag and abrasion resistance. With these properties it is particularly suited for bottom blocks and those top areas of the furnace which are exposed to severe abrasion by the furnace charge.

SUPERAC-K-BF (NS)—another variety of SUPERAC-K-BF blast furnace brick, are expressly manufactured for increased spalling resistance, for lower inwalls where this property is sometimes of benefit.

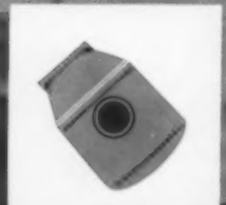
400 MILLION TONS of HOT Metal Skill

Now celebrating 80 years of hot metal experience . . . PECor is famous for equipment that stays-on-the-line making steel. Strong, safe, quality units backed by service which includes immediate response to field requirements!

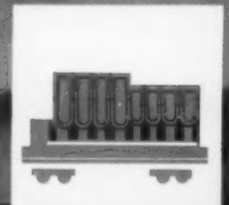
May we consult with you in the planning stage—for standard PECor products or special fabrications?

BACKGROUND: ONE OF 15 PECOR BASIC OXYGEN VESSELS IN THE TAPPING OPERATION.

OXYGEN VESSELS



STEEL MILL CARS



LADLES

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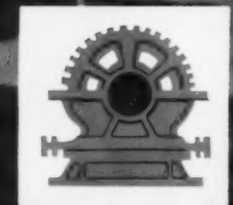

Pennsylvania Engineering

CORPORATION NEW CASTLE, PA

Sales Representatives: Wooldridge Company, Burlingame, Calif.
Fred Middleton Co., Inc., Birmingham, Ala

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Kawasaki Dockyard Company, Ltd., Japan

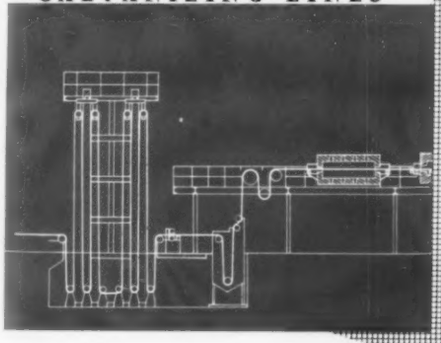
BUILDER OF AMERICA'S FIRST 15 OXYGEN CONVERTERS

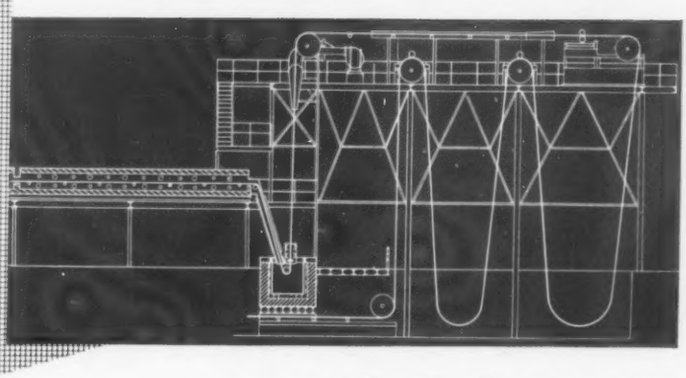
FURNACES AND HEATING EQUIPMENT

General view of two galvanizing lines constructed for S.A. Phenix Works at Flemalle-Haute (Belgium).

HEURTEY

HEURTEY - SENDZIMIR CONTINUOUS WIDE STRIP GALVANIZING LINES





world references

PARIS - LIEGE - LYONS - MADRID - MILAN - VÄSTERÄS

HEURTEY constructed in FRANCE, BELGIUM and LUXEMBURG a large number of SENDZIMIR lines either as straight or as recuperative furnaces for a range of production of 3 - 10 t/h. Identical lines can also be designed for a production up to 20 t/h.

HEURTEY

38, AVENUE GEORGES MANDEL - PARIS

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A. 187 ang. - PUB. JMRabec

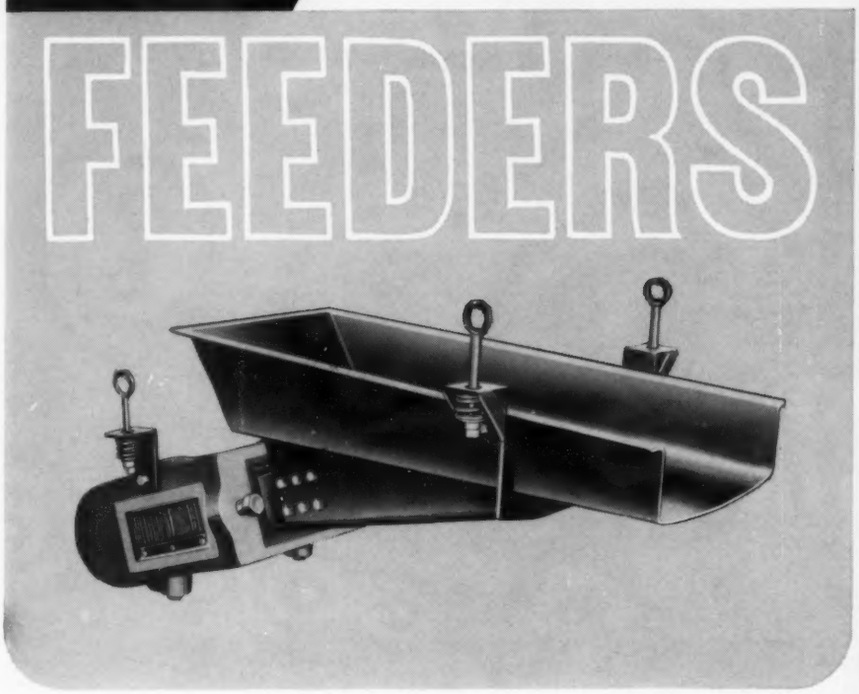
A roll's life holds no secrets

Men like National's metallurgist Joe Marsalka see to that. Before your roll is born, National helps select the proper composition, grade and hardness. As it is being produced, our metallurgists carefully control chill locations, pouring procedures and heat treatment. When the roll is "full-grown" ultra-sonic testing equipment checks its internal soundness making sure your roll is ready for the tough life ahead. Even after your roll is shipped, National keeps in touch with its performance in your stand. This intimate knowledge of roll life is one reason we are able to consistently produce quality steel, iron and nodular iron rolls. It's a big reason why... NATIONAL'S THE GROWING NAME IN ROLLS.

NATIONAL ROLL & FOUNDRY DIVISION
GENERAL STEEL CASTINGS CORPORATION, Avonmore, Pennsylvania
General Steel Castings Corporation, General Offices: Granite City, Ill. Plants: Granite City, Ill., Eddystone, Pa., Avonmore, Pa.
Subsidiary: St. Louis Car Company, St. Louis, Mo.

REDUCE BULK MATERIALS HANDLING COST

SYNTRON VIBRATORY FEEDERS



EFFICIENCY, DEPENDABILITY HIGH CAPACITY, LOW MAINTENANCE

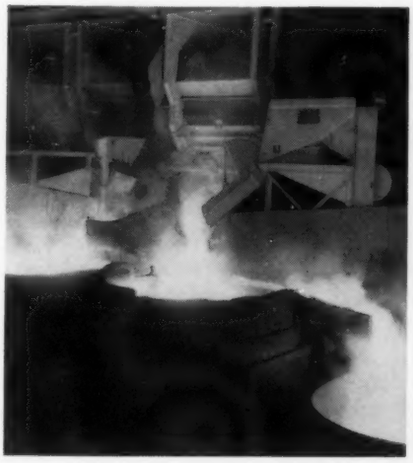
More and more basic steel plants are specifying Syntron Vibratory Feeders as an integral part of their vast production system for low cost, dependable bulk materials handling between storage and process equipment or process to process equipment.

Syntron Vibratory Feeders combine efficiency, dependability, accuracy and high ton per hour capacity, variable control of amplitude provides a fully adjustable high-low feed rate cycle from torrent to dribble. Manual or automatic control.

Simplified electromagnetic drive eliminates all moving wearing parts—gears, belts, pulleys, etc., lowering maintenance costs.

Available with above or below deck drive —floor or suspension mounting—flat pan or tubular type troughs.

Feeders to meet every tonnage requirement.



Write for Syntron Catalog #605 and the name of the Syntron Representative nearest you.

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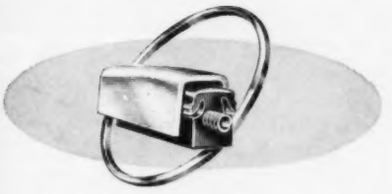
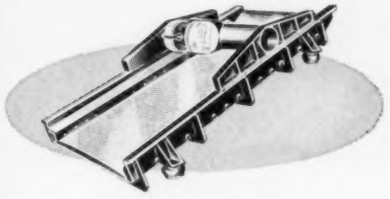
Other SYNTRON equipment of proven dependable quality

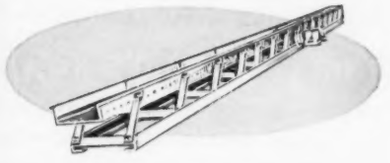


Roll Neck Seals



Vibrating Screens

Rectifier Power Units



Mechanical Vibrating Conveyors

Test Sieve Shakers

SYNTRON

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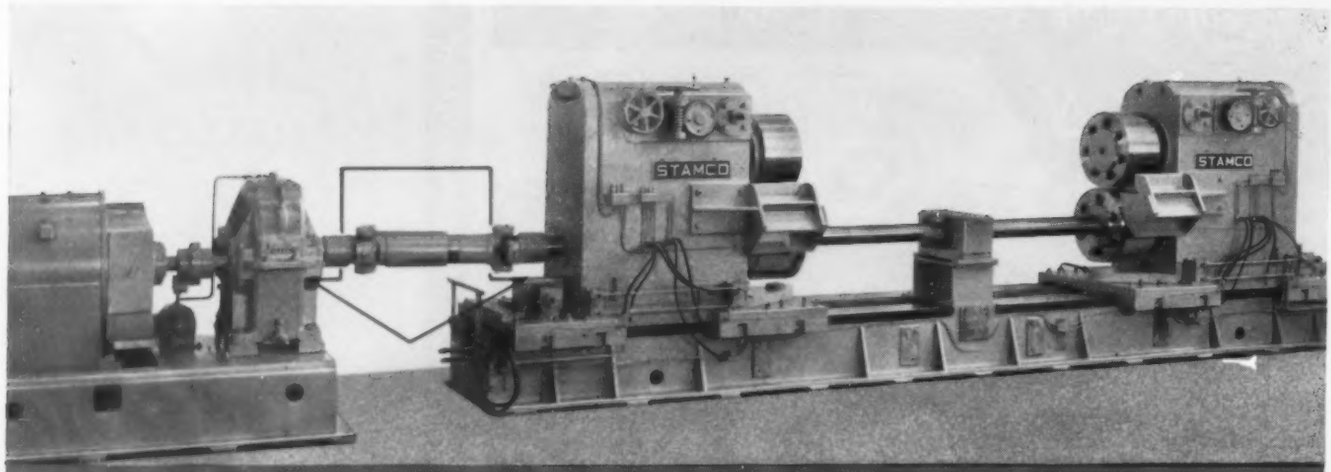
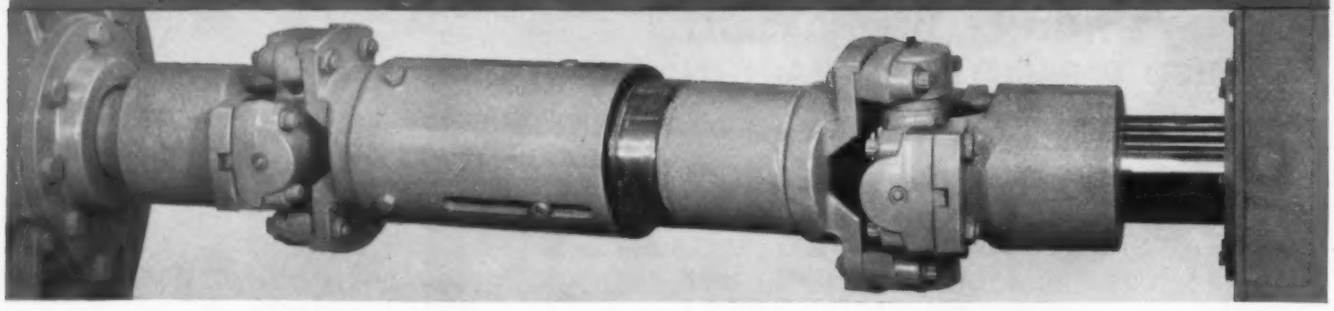
699 Lexington Avenue • Homer City, Pa.



BLOOD BROTHERS "150WB" UNIVERSAL JOINT

MADE THIS STAMCO HOT MILL SIDE TRIMMER POSSIBLE



This Mammoth, custom-built Stamco machine weighs 85,000 pounds. Equipped with 24-inch diameter cutters and star type scrap choppers it can make two cuts of .300-inch in hot aluminum at the amazing rate of 1200 feet per minute!

During design stage, Stamco ran into a power transmission problem they had never encountered before. The coupling housing not only moved in and out for width but also had an angular movement of 3°. A coupling was needed to withstand heavy wear as well as the strain of the angular movement.

Stamco called in Rockwell-Standard engineers who recommended their largest universal joint, the Blood Brothers "150WB." The "150WB" easily handles 162,000 inch pounds of torque using a safety factor of 10 to 1 . . . in a swing diameter of only 13½ inches! A specially-designed "150WB" solved Stamco's problem, enabled them to satisfy their customer with a dependable, big-capacity unit.

Rockwell-Standard specialists can design and build *any* universal joint you need. Their wide experience and complete manufacturing facilities assure you of the most efficient performance at the most favorable price. Call or write today for further information.

Another Product of... **ROCKWELL-STANDARD CORPORATION**

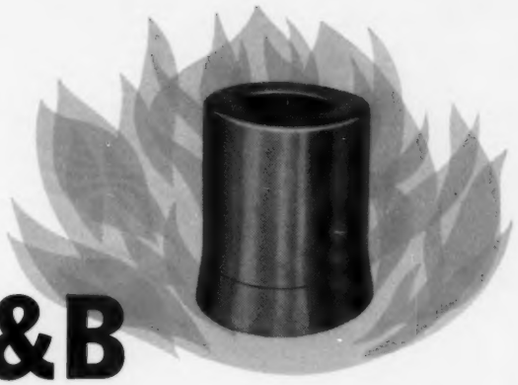
ROCKWELL R STANDARD

Universal Joint Division, Allegan, Michigan

AVERAGE LIFE: PB&B TUYERES WITH 90% MINIMUM CONDUCTIVITY

AVERAGE LIFE: TUYERES WITH 48%-72% CONDUCTIVITY

AVERAGE LIFE: TUYERES WITH 42%-52% CONDUCTIVITY



PB&B HIGH CONDUCTIVITY COPPER

lasts 62-85% longer
costs 20-34% less per day

Your furnace copper dollar buys more when you use PB&B high conductivity copper parts. Take tuyeres, for instance. This chart shows the actual service life of tuyeres of different conductivity copper under *equal operating conditions as measured in a recent test in a major steel mill.* PB&B high conductivity tuyeres far outlasted ordinary tuyeres . . . actually cost far less per day of service.

Only copper of the highest conductivity is used in PB&B components. Castings are virgin electrolytic copper, certified at 90% IACS minimum conductivity. Our forgings are OFHC* copper, guaranteed at least 98% IACS conductivity.

PB&B has developed unusual designs that utilize high conductivity copper to its fullest capability. Exclusive PB&B methods make possible copper castings with cast-in-place copper tubing** that boosts cooling efficiency. In our Hoffman bosh and stack plates, dual cooling chambers give maximum protection at hottest points; chambers can be operated independently of one another if necessary. We can supply conventional designs, too, in 90% minimum conductivity copper.

See how the PB&B combination of high conductivity and unique design can bring the economies of longer life and improved cooling to all your steel mill copper—*oxygen lance jet heads, roof coolers, monkeys, tuyeres, and bosh and stack plates.* Write today for data and for proposals on your specific requirements.

**Registered Trade Mark—American Metal Climax, Inc.*
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Furnace Products Division

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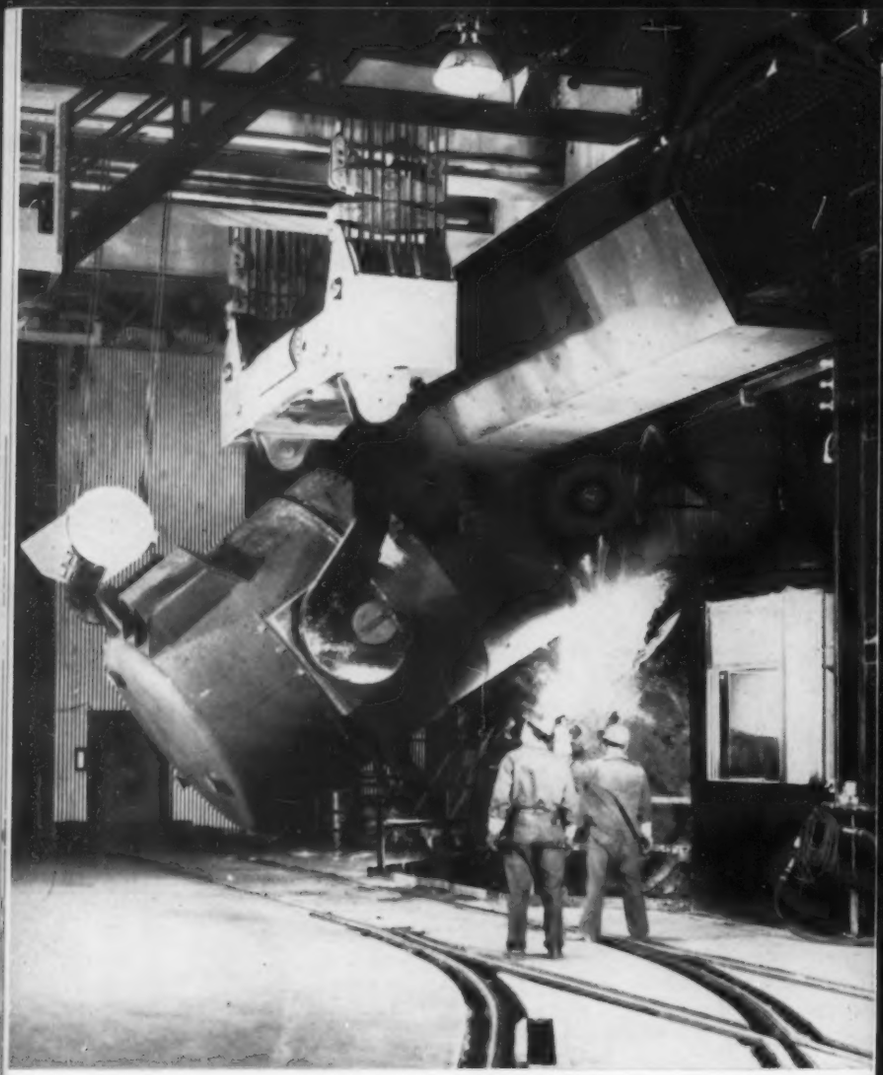


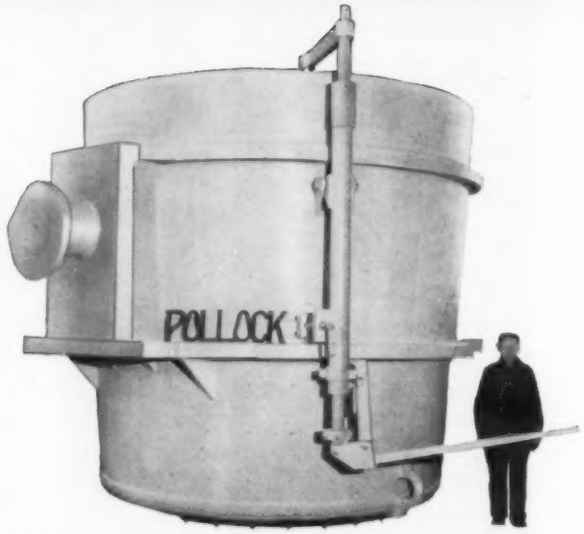
80-ton capacity Pollock ladle pouring iron charge into one of the new basic oxygen furnaces at the Aliquippa Works Division of Jones & Laughlin Steel Corporation.

The Industry's STANDARD

POLLOCK LADLES

Pollock ladles, like the one at left, are engineered for the jobs they do. This one was engineered and built for the Jones & Laughlin Steel Corporation, Aliquippa Works Division, to transport molten iron from the mixer ladle to the new basic oxygen process furnace. Its integral spout eliminates the old-fashioned runner used in most pouring operations, and the feet mounted on the ladle base make the ladle free standing. Pollock also built the ladles to receive the steel from the new furnaces. When you plan new facilities or increased capacity in your present plant, consult the Pollock engineers about your ladles. They'll work with you to develop new highs in efficiency and safety.

385-ton capacity open hearth ladle built by Pollock is the world's largest. It stands 17' 3-½" tall.



100-ton capacity all-welded electric furnace ladle by Pollock. All-welded construction cuts ladle weight—increases payload.

POLLOCK
SINCE 1863

THE WILLIAM B. POLLOCK COMPANY
YOUNGSTOWN, OHIO

Associated in Great Britain with Ashmore, Benson, Pease & Co.

ENGINEERS, FABRICATORS AND ERECTORS OF BLAST FURNACE STEEL WORK . . . HOT METAL AND SLAG HANDLING EQUIPMENT FOR . . . BLAST FURNACE, OPEN HEARTH AND ELECTRIC FURNACE PLANTS

Electric and open hearth steel castings from 1 lb. to 100 tons.

Rolling on a PITTSBURGH Breakdown Mill at ANACONDA ALUMINUM

As a major part of [illegible] expansion program at its [illegible] Indiana plant, Anaconda Aluminum Co. has installed this PITTSBURGH 66-inch four-high cold rolling Breakdown Mill. This equipment produces aluminum strip with a minimum thickness of .012" up to 60" wide at a speed of 1,200 feet per minute to help meet the increasing volume of orders specifying exacting gauge tolerances and surface quality. The mill also produces foil stock for Anaconda Aluminum's Foil Division at Louisville, Kentucky.

Important design features of this PITTSBURGH mill include hydraulic roll crown control, special reel drives to provide added flexibility and strip gauging equipment for automatic gauge control.

For all your requirements in rolling mill equipment and related facilities, contact PITTSBURGH.

PITTSBURGH

ENGINEERING & MACHINE DIVISION

Pittsburgh Steel Foundry Co., Textron Inc.

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If you need lots of pipe or tube... YODER makes the mills that make it!

For complete information on YODER Pipe or Tube Mills . . . write for the fully illustrated, 88 page YODER Tube Mill Book . . . it is yours for the asking.

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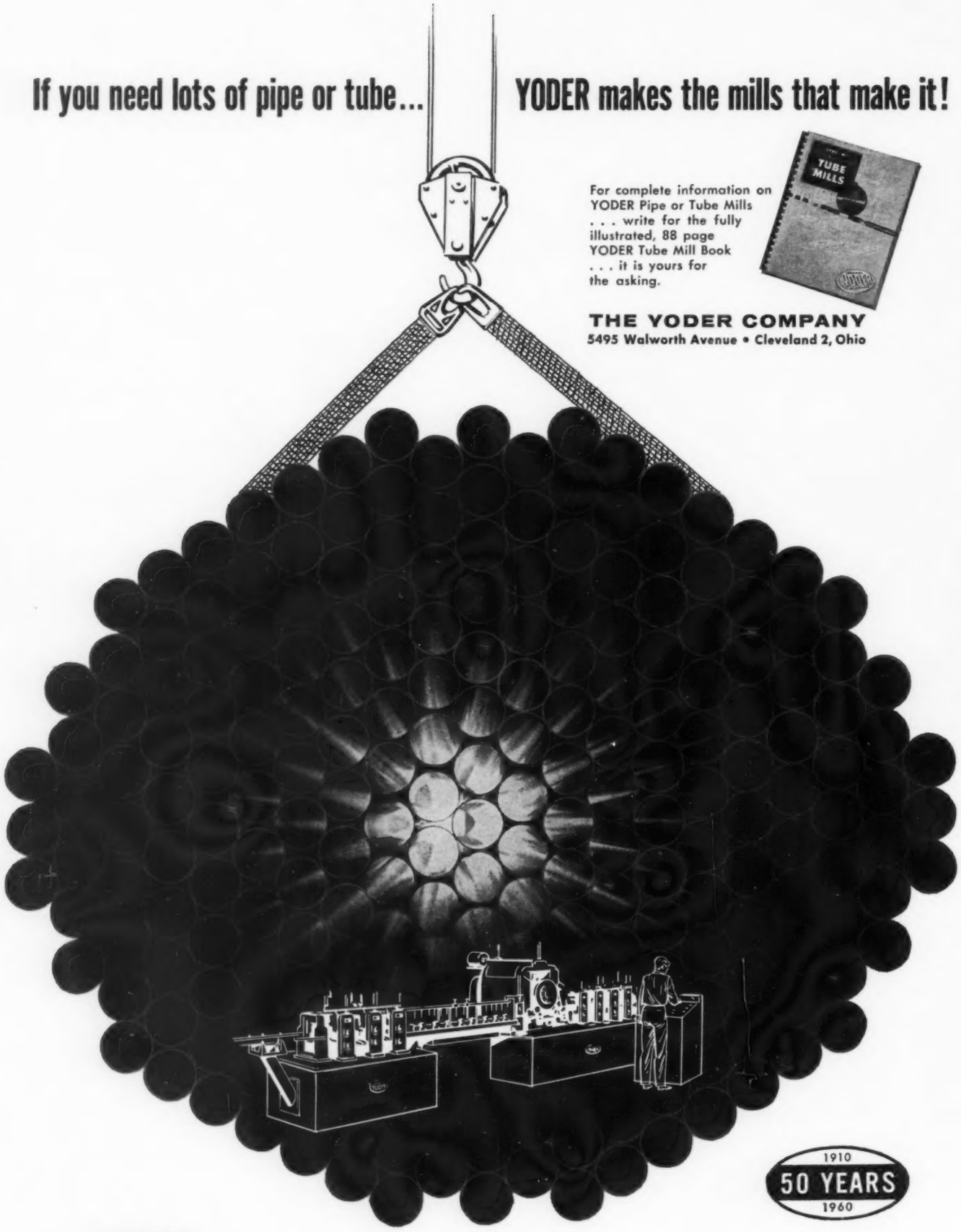

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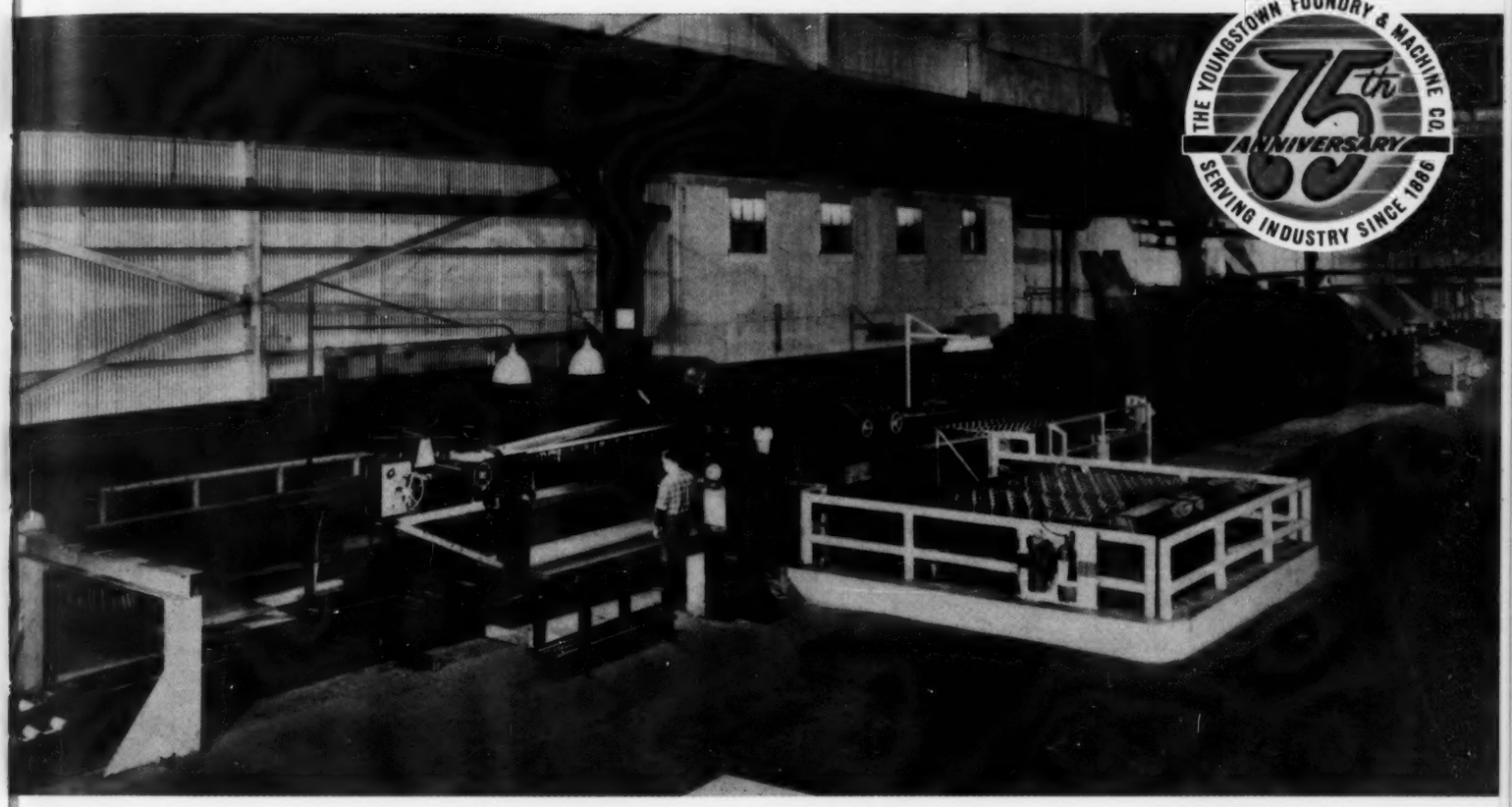
ENGINEERING YODER MANUFACTURING

PIPE AND TUBE MILLS (ferrous or non-ferrous)

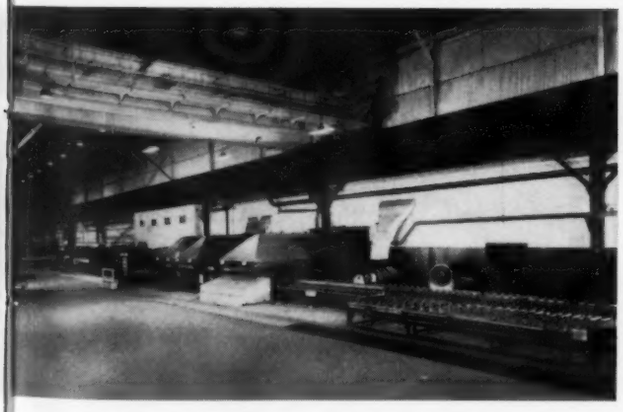
COLD ROLL FORMING MACHINES

ROTARY SLITTING LINES

"YOUNGSTOWN"
81" SHEET SCRUBBER LINE



...built for United States Steel's Irvin Works
Dravosburg, Pa.



Entry end of "Youngstown" 81" sheet scrubber line at United States Steel's Irvin Works.

This ultra modern 500 fpm scrubber line is designed to increase tonnage per turn, in cleaning steel sheets up to 76" wide and .250" thick.

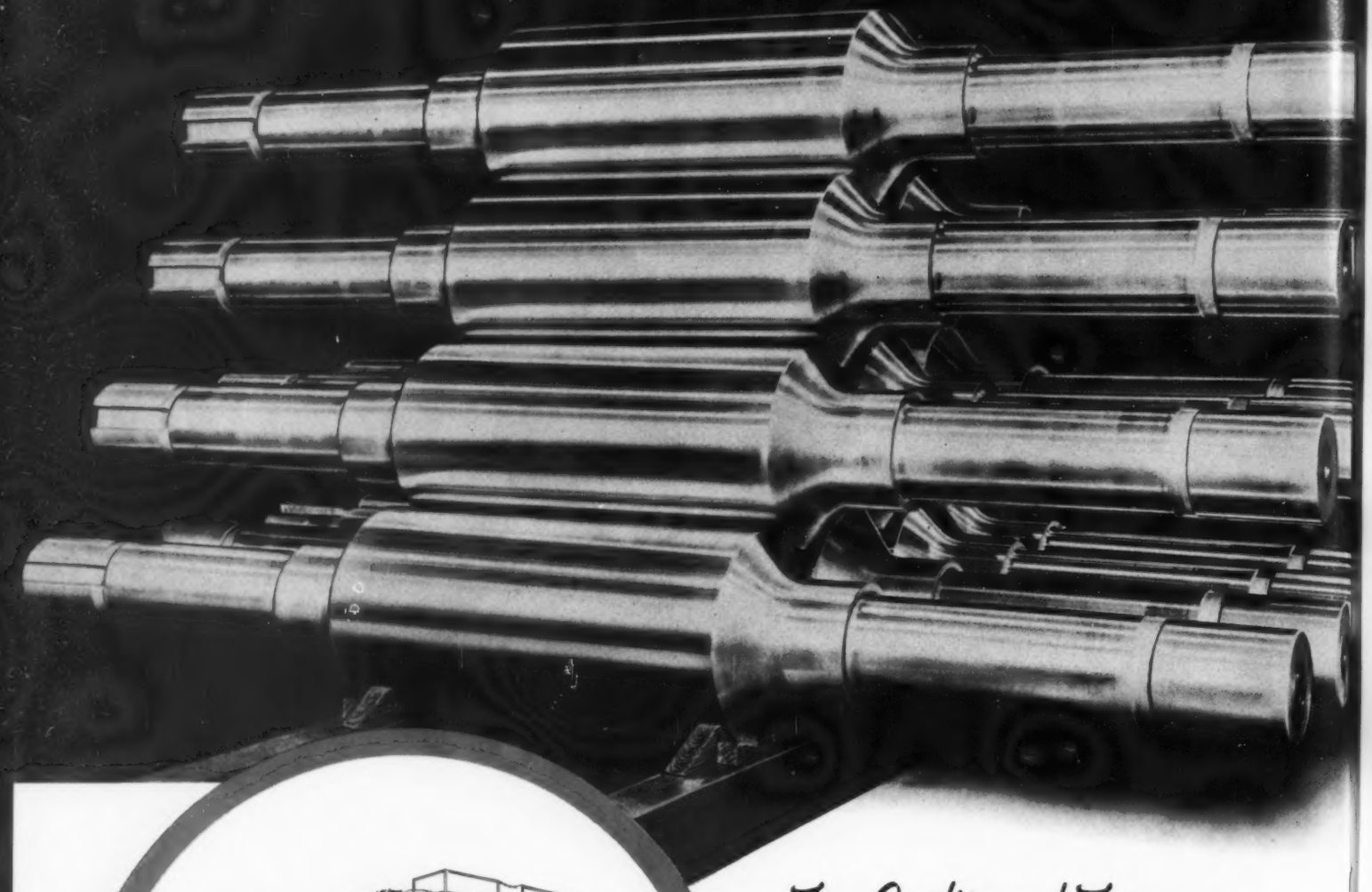
The line was furnished complete including unloading conveyor, skew conveyor, acid spray unit, water spray unit, alkali spray unit, hydro scrubber unit, sheet dryer, cooling system and conveyors, and all auxiliary equipment including acid proportioning, dry met, fume exhaust system, electric motors and controls, air conditioned electrical control station, installation, erection, and foundation engineering.

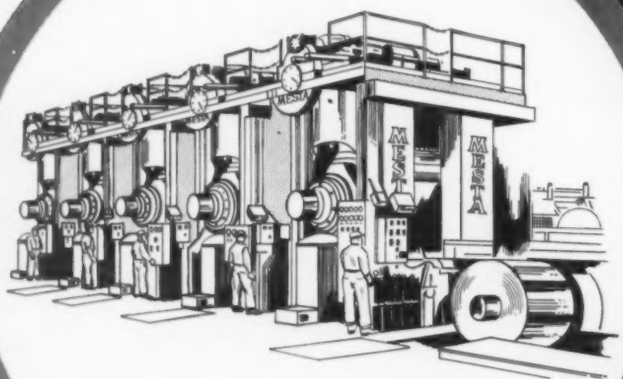
You can rely on "Youngstown's" 75 years of scrubbing, pickling and cleaning know how. Your inquiries are invited whether you require a complete turnkey installation or any auxiliary component.

The Youngstown Foundry & Machine Co.

Youngstown 1, Ohio

MESTA ROLLS





For Quality and Tonnage...

MESTA Forged Hardened Alloy Steel Working Rolls for ferrous or non-ferrous Cold Mills and non-ferrous Hot Mills.

Designers and Builders of Complete Steel Plants

MESTA MACHINE COMPANY

PITTSBURGH, PENNSYLVANIA

Personnel News...

J. Donald Rollins was named president, American Bridge Division, United States Steel Corp. He joined U. S. Steel in 1934, with the American Sheet & Tin Plate Co., as an estimator. He has held various engineering positions including chief engineer—Gary Works; assistant chief engineer for Carnegie-Illinois, a former subsidiary company; assistant chief engineer—manufacturing, U. S. Steel; and assistant vice president—engineering for the corporation. While in this position he served as project manager for the construction of Fairless Works. Starting in 1955 he was vice president—engineering for American Bridge Division. Returning to the corporation in 1958 as vice president—facility planning, he was appointed to the position of vice president—facility planning and appropriations in March, 1960.

Norman C. Michels succeeds Mr. Rollins as vice president—facility planning and appropriations, United States Steel Corp. Mr. Michels comes to Pittsburgh from Birmingham, Ala., where he has been serving U. S. Steel's Tennessee Coal & Iron Division as vice president—engineering for the past five years. **R. W. Holman** succeeds Mr. Michels as vice president—engineering of TC & I. Mr. Michels' first employment with U. S. Steel was as special engineer at the Carnegie-Illinois Steel Corp., Pittsburgh, in 1941. The following year, he was transferred to Carnegie-Illinois' Gary, Ind., operations, to work as an expediter. He became assistant project engineer there in 1944. He returned to Pittsburgh as a planning engineer in 1950 and worked in this capacity until he was appointed chief engineer—project development, U. S. Steel Corp. in Pittsburgh in 1952. Mr. Michels went to Birmingham as assistant vice president—engineering 1954, and was promoted to vice president—engineering, Tennessee Coal & Iron Division, in 1955. Mr. Holman has been serving since 1958, as division chief engineer for TCI, having come to Birmingham from Pittsburgh at that time. Associated with United States Steel since 1935, he began in the Electrical Department of the Gary, Ind., Sheet and Tin Mill. He progressed through various supervisory positions to become assistant general superintendent of that works. He was made assistant vice president—research and technology in 1954.

Walter T. Haswell, Jr., works manager of Latrobe Steel Co. for the past five years, has been named vice president in charge of production to succeed **R. T. Eakin,** who resigned. Joining the company in 1945 as a mill metallurgist, Mr. Haswell served as assistant superintendent of the Cold Finishing Department, assistant production manager of the Hot Mills Department, and superintendent of the Cold Finish Department, before becoming works manager in 1955.

Howard E. Miller has been appointed chief metallurgist of Republic Steel Corp.'s Cleveland District steel plant. Assistant chief metallurgist for the district since 1955, he succeeds the late **H. L. Farling.** Succeeding Mr. Miller as assistant chief metallurgist will be **C. J. Schaefer.** Mr. Miller joined Republic in 1938 as a tester in the hot strip mill. In 1942, he was named general metallurgical foreman of the cold strip mill and three years later, general metallurgical foreman of the hot strip mill. He was appointed strip mill metallurgist in 1946 and became contact metallurgist in 1953. Mr. Schaefer joined Republic in 1941 as a metallurgical trainee. Prior to his new appointment he served as general metallurgist for the district's 98 in. strip mill.

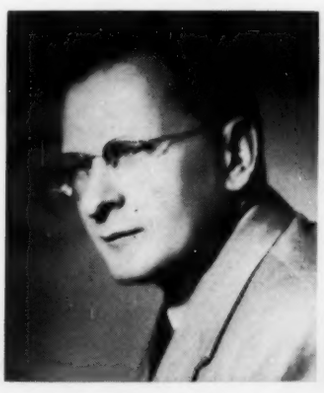
Richard E. Garner has been appointed superintendent of the Industrial Engineering Department at Kaiser Steel Corp.'s Fontana, Calif., plant. He joined Kaiser in 1952 as a junior industrial engineer. He advanced to industrial engineer, senior industrial engineer, supervisor and assumed a division responsibility in 1959, the position he held until his present appointment.

James L. Roemer, Jr., was appointed superintendent, of the butt weld pipe mills at the Indiana Harbor Works of The Youngstown Sheet and Tube Co. At the same time, **James R. Hanlon, Jr.,** was named general foreman of continuous weld furnaces; **Michael Spin,** general foreman of Continuous Butt Weld Finishing

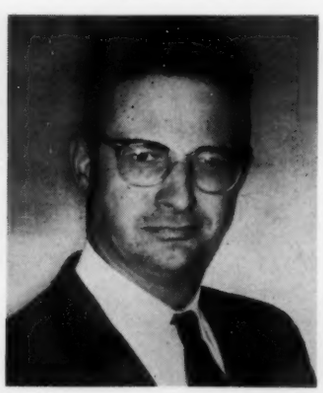
J. D. ROLLINS

N. C. MICHELS

R. W. HOLMAN



W. T. HASWELL, JR.



Department; and **Harry Sutton, Jr.,** general foreman, galvanize and conduit unit. Mr. Roemer joined Youngstown in 1930, and was formerly superintendent of butt weld operations at the company's Campbell Works.

Fletcher L. Byrom was elected president of Koppers Co. Inc. Mr. Byrom and **Walter P. Arnold,** executive vice president, also were elected to the board of directors. **Fred C. Foy,** who has held the dual position of chairman and president of Koppers since 1958, will continue to serve as chief executive officer. Mr. Byrom, who was vice president and general manager of the company's Tar Products Division prior to his election, will be chief administrative officer.

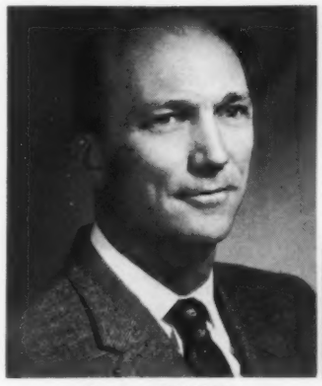
Arthur W. Thornton has been appointed director of engineering and research of National Tube Division, U. S. Steel Corp. Mr. Thornton had been general superintendent of the division's Lorain, Ohio, Works. In this newly created position, he will be responsible for all engineering and research activities of National Tube Division. Succeeding Mr. Thornton at Lorain Works is **William L. Fader,** who has been assistant general superintendent at that plant. Mr. Thornton's association with National Tube began in 1926 when he took the first of a series of summer positions at the division's Christy Park Works. After working several years for Duquesne Works of the former Carnegie-Illinois Steel Corp., Mr. Thornton transferred to National Works of National Tube in 1934 as a steel works metallurgist. He remained there for 20 years, serving successively as assistant superintendent of the Open Hearth and Bessemer Department, superintendent of the Department, division superintendent of the steel works, division superintendent of the pipe mills and, finally, as assistant general superintendent of the plant. In 1954, he was transferred to the Pittsburgh headquarters of National Tube as assistant to the vice president of operations, and in January, 1960, was made general superintendent of Lorain Works. Mr. Fader joined National Tube at its Christy Park Works in 1950. He rose to general superintendent of that plant, and in 1954, was appointed assistant general superintendent of National Works. In 1957 he was made assistant general superintendent of the Lorain Works.

Alvin J. Scheel has been appointed assistant general superintendent at Lorain Works of National Tube Division, U. S. Steel Corp. He has been general superintendent of National Tube's Fairless Works since 1957. He began his career with National Tube at Lorain Works in 1933. Four years later he was made a foreman in the rolling mills, later becoming general foreman there. In 1947, Mr. Scheel was transferred to the Division's National Works as assistant superintendent of rolling mills. In 1950, he became superintendent of that department, and in 1954 became superintendent of the Open Hearth and Bessemer Department. In 1955, he was named assistant general superintendent at Fairless.

Howard N. Hubbard succeeds Mr. Scheel as general superintendent at Fairless. Mr. Hubbard has been assistant general superintendent of National Works since 1957. He began his career with National Tube at Lorain Works. In 1941, he was made assistant superintendent of the open hearth and foundries. In 1954 he was made division superintendent of the steelmaking operations at Lorain. He held this post until his promotion to National Works.

F. L. BYROM

A. W. THORNTON



A. J. SCHEEL

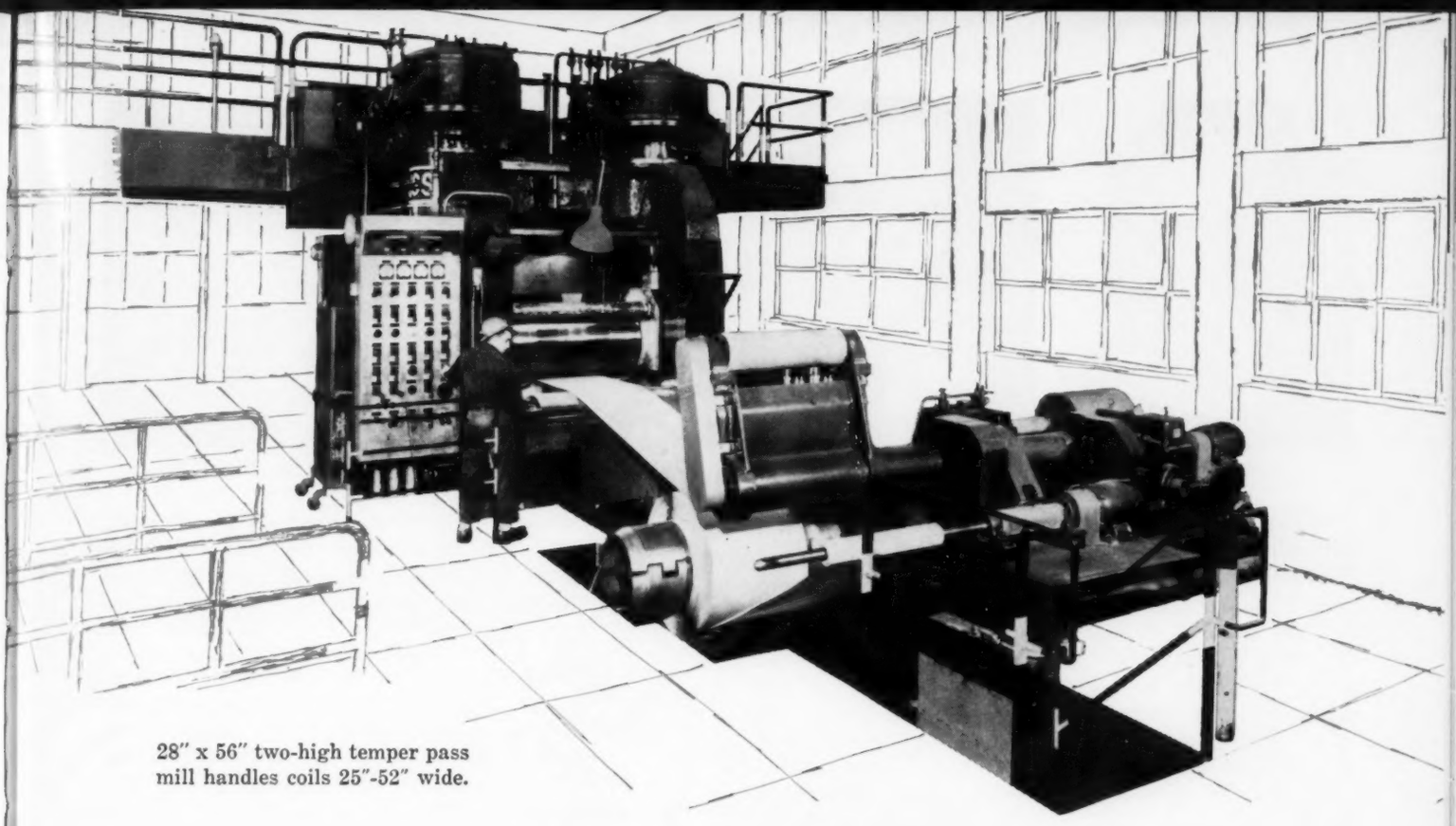
H. N. HUBBARD

J. P. ELY

H. A. SIEFEN

John P. Ely was named assistant general superintendent of the National Works, succeeding Mr. Hubbard. Mr. Ely's entire career has been served at National Works. He joined the old National Tube Co. at McKeesport in 1936 as metallurgical observer in the Rolling Mills Department. After short periods as a steel distributor and technical investigator, Mr. Ely moved into the Open Hearth and Bessemer Department, becoming its superintendent in 1952. Early in 1954, he became assistant to general superintendent of National Works and later that year division superintendent, blast furnaces, open hearths, bessemer and rolling mills. He has held that post until this assignment.

Harry A. Siefen has been appointed assistant general superintendent of Christy Park Works, National Tube



28" x 56" two-high temper pass mill handles coils 25"-52" wide.

Now 2 new Bliss mills help keep tempers under control at Gary Sheet & Tin

Until last summer, Gary Sheet & Tin tempered "stainless" on the temper mills used for carbon steel. Then to add a new dimension of efficiency, the plant decided to set up separate facilities for stainless and installed a new Bliss temper pass mill to handle it.

Product of Gary and Bliss thinking, the mill takes coils as wide as 52", as narrow as 25"; tempers gages from .008-.150" to an average hardness of 83 Rockwell. Result: this plant of U.S. Steel is now more able to take heavy workloads and special orders in stride.

Another Bliss temper mill is paying similar dividends in Gary's continuous pickling line. Key addition of an April '59 expansion program, this 34" x 76" two-high mill with husky entry and delivery bridles enables Gary to handle strip 18"-62" wide, in thicknesses from .059"-.187". It reduces stock 1½-2%, serving to fracture the scale, thus resulting in less pickle liquor required and higher pickling rate.

Can a custom-designed Bliss mill help you solve a profit-robbing problem? See how the Rolling Mill Division has assisted other plants. Write today for our 84-page Bulletin 40-B.

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SINCE 1857

Bliss is more than a name
...it's a guarantee

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Salem, Ohio

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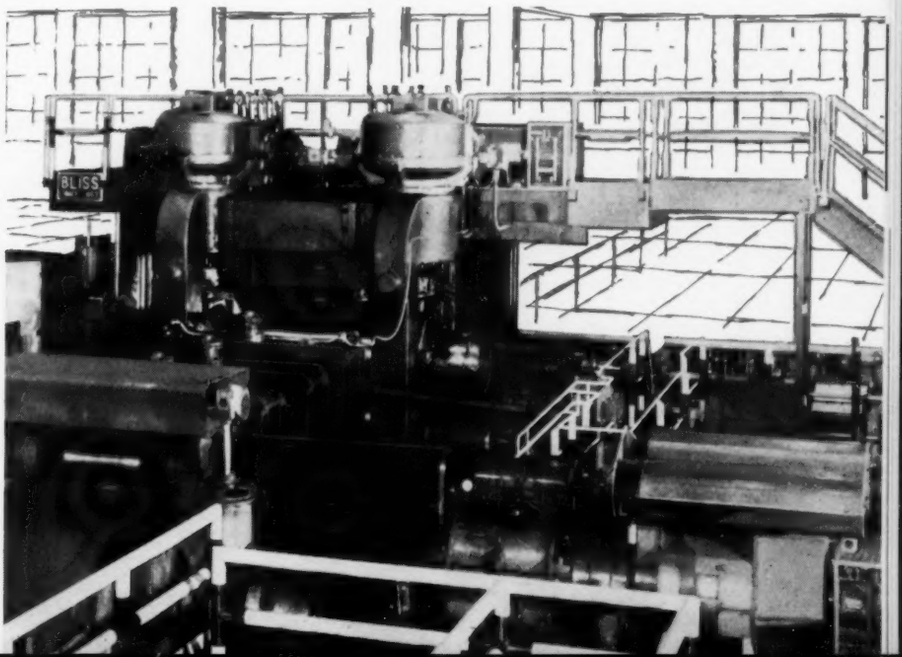


34" x 76" two-high mill in Gary's continuous pickling line descales and tempers at the same time.

J. L. THOMAN

JEROME BROWN

ROLF LINDENHAYN, JR.

J. M. BROWN

Division, U. S. Steel Corp. He had been assistant to the general superintendent at National Tube's National Works. Mr. Siefen has spent his entire working career with National Tube, beginning with summer vacations in 1936. He joined the student engineering course at National Works in 1939. He held a number of positions in the Operating Department there, and in 1946, was appointed supervisor, pipe mill observers, and a year later was made general foreman in the special finish department of pipe mills. Mr. Siefen was appointed assistant superintendent of the Finishing Department in 1953 and in 1958 was made assistant to the general superintendent.

John L. Thoman has been appointed manager of operations at the Kenilworth, N. J., plant of Jones & Laughlin Steel Corp.'s Stainless and Strip Division. He formerly was division industrial engineer at the Stainless and Strip Division headquarters in Detroit, Mich. **Jerome Brown** has been named division industrial engineer. He previously was Detroit plant industrial engineer.

Rolf Lindenhayn, Jr., has been appointed western division manager of brush and railroad products for National Carbon Co., Division of Union Carbide Corp. He succeeds **H. D. VanArtsdale,** who has assumed new responsibilities with Union Carbide International Co. Mr. Lindenhayn joined National Carbon in 1941 and was assigned to carbon products sales in St. Louis, Mo. Mr. Lindenhayn has been located in Cincinnati since 1946. He was a chemical products salesman until 1949, a carbon products salesman until 1954, and most recently an electrode products salesman. **James M.**

EXECUTIVE REPORT '30

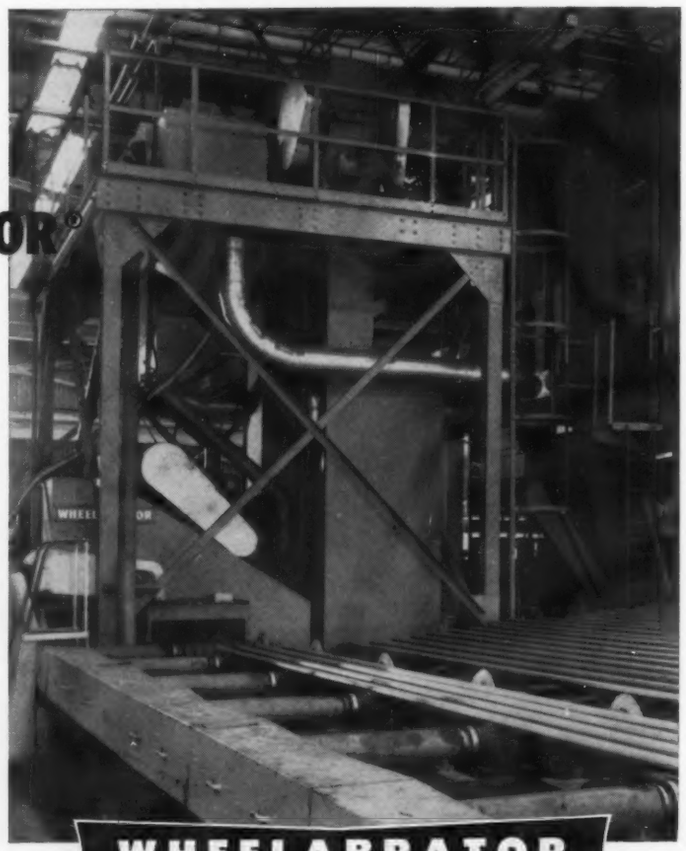
AUTOMATED DESCALING WITH THE WHEELABRATOR®

The bar stock cleaning line in the new two million dollar Elyria, Ohio, Cold Draw plant of The Western Automatic Machine Screw Co., Div. of Standard Screw Co. utilizes one of six Wheelabrator descaling machines that have completely eliminated pickling in this modern plant.

On the bar line, the Wheelabrator enables one man to handle the entire operation, from receipt of bar bundles, through an unscrambler, transfer to feed roll conveyors, through the Wheelabrator, and out onto a storage rack in line with the draw bench. For over 16 months of operation, round, square and hex bar stock, up to 4½" diameter in 15' to 45' lengths, has been descaled without any of the old acid pickling headaches. In addition, Western Automatic reports that Wheelabrator descaling provides a definitely superior product for subsequent cold drawing.

How To Automate Your Bar and Wire Drawing Lines

Details of Wheelabrator's cost-saving descaling method are illustrated in Bulletin 148-D. Write to Wheelabrator Corp., 396 S. Byrkit St., Mishawaka, Indiana. In Canada, P.O. Box 490, Scarborough, Ontario.



WHEELABRATOR
AIRLESS BLAST EQUIPMENT

CHARLES SCHWARZLER

H. O. EHRISMAN

V. V. TIVY

N. C. RUBIN

Brown succeeds Mr. Lindenhayn as electrode products salesman in Cincinnati. Mr. Brown joined National Carbon in 1949 as a chemical products equipment engineer in Cleveland, and was assigned as a chemical products salesman in Portland, Ore., in 1954. He went to Atlanta, Ga., in a similar position in 1955, and to Birmingham, Ala., in 1956. Since 1958, he has been a chemical products equipment salesman in Chicago.

C. Schwarzler has been appointed vice president of The Foxboro Co.'s newly-created Marketing Division. He will be responsible for planning and directing the development of new market areas and disseminating Foxboro instrument engineering information throughout the world. He will also direct the company's sales promotion and publication activities. **H. O. Ehrisman** was named vice president and U. S. general sales manager. **V. V. Tivy** has been appointed director of engineering, and will also continue as head of the Systems Engineering Division.

Norbert C. Rubin, who has been with Yoder Co. since 1939 in engineering and sales, and a vice president since 1946, has resigned to open a private office as a technical and export consultant. He will do part-time consultant work for Yoder in the development and application of new equipment in the tube, pipe and metals industries. The balance of his time will be directed to similar fields in the European and British areas.

Lloyd H. Paulsen was named to the position of general sales manager, Refractories Division, Gladding, McBean & Co. Mr. Paulsen succeeds the late **Joseph**

EXECUTIVE REPORT #12

A PIPE DREAM COMES TRUE

Wheelabrator® cleans skelp edges at new low cost

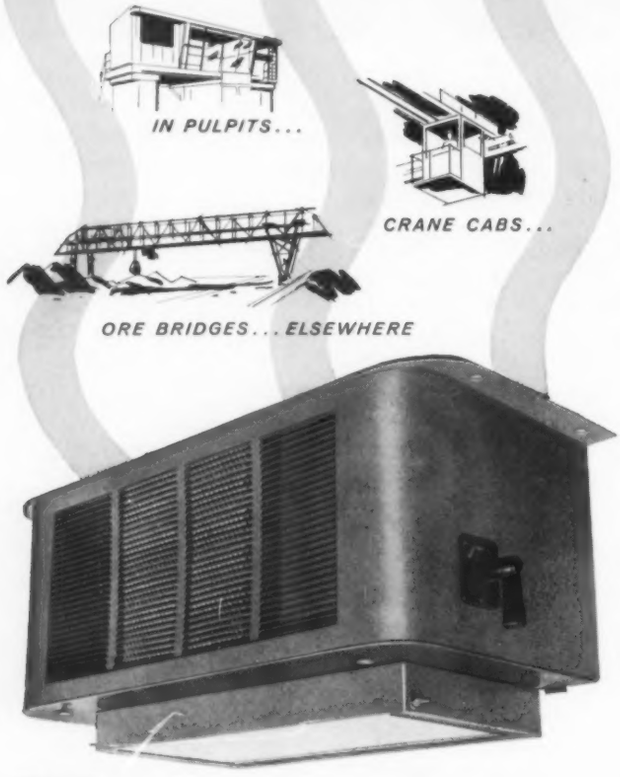
Another example of steel industry savings made possible by Wheelabrator mechanical descaling is the exceptional economy realized by pipe rolling mills in cleaning of skelp. Here it is desired to clean only a small strip along both edges of the bottom side of the skelp, which will be butted together and electro-welded.

In the Wheelabrator process, two blasting wheels are positioned to pinpoint their abrasive barrage along the edges, giving fast, thorough cleaning of these surfaces only.

Wheelabrator leads in mechanizing steel mill descaling methods

In over 100 installations in all types of steel mill applications, Wheelabrator has proven its cost-saving benefits. For engineering consultation call or write Wheelabrator Corporation, 396 S. Byrkit St., Mishawaka, Indiana. In Canada, P. O. Box 490, Scarborough, Ontario.

Warmth for isolated workers



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Circulates... Ventilates **HEATER**

The Lintern Heater takes less space and yet provides more effective heat distribution than any heater previously offered for crane cabs, watchmen's shanties and similar confined areas. An optional filter is available where dirt is a problem. Installs on ceiling, wall or floor. Low in cost, compact in size, light in weight, highly dependable. Available in all AC or DC voltages.

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R. Rhodes. Since his affiliation with Gladding, McBean in 1946, Mr. Paulsen has served as area sales manager in both San Francisco and Los Angeles.

Dan L. McGurk has been named director of marketing for TRW Computers Co., the industrial control computer division of Thompson Ramo Wooldridge Inc. Mr. McGurk joined the company in 1958 as proposals and contracts manager. He was named sales manager in 1959, a position he held until his appointment as director of marketing.

Harvey Bradley, formerly in the Engineering Department of the Steel Co., of Canada, Ltd., has been appointed service and development engineer for Mansaver Industries.

Stanley B. White has been appointed as vice president, manufacturing (aluminum) for Kaiser Aluminum & Chemical Corp. He had been serving as vice president and general manager of Kaiser Aluminum's industrial division.

Fred J. Robbins has been elected president and chief administrative officer of Bliss & Laughlin, Inc. At the same time **Philip L. Ray** was elected chairman of the board of directors and **C. Arnold Kalman** was elected chairman of the executive committee. Mr. Robbins, who has also been elected to the board of directors, succeeds **Arthur Lehr** who died October 29.

Frank Mosko, formerly sales manager, has been appointed vice president, engineering contact for the David W. Murray Co. Mr. Mosko previously was assistant to the first vice president of Aetna-Standard Engineering Co. prior to that he worked in the Design Engineering and Construction Department of U. S. Steel Corp's. Irvin Works.

Paul J. Kunkler has been appointed sales manager of The Vaughn Machinery Co., and **Ralph B. Long, Jr.,** has been named divisional sales manager—bar and tube drawing.

Arley J. Ball has been appointed Eastern regional sales manager of Hewitt-Robins Inc., succeeding **Norman M. Godfrey,** recently named manager of operations of the company's Robins Conveyors Division.

Michael J. Joncich, general sales manager of Datex Corp. has been elected vice president. Mr. Joncich has been with Datex since 1953 as sales engineer, regional sales manager, assistant sales manager and general sales manager.

Obituary

Harold E. Taylor, Superintendent, Coke and Chemicals Department, Alan Wood Steel Co., died November 22. He was 60. He joined Alan Wood in 1929 as general oven foreman. He was appointed assistant superintendent, coke and chemicals in 1945, and superintendent in 1956.

Paul M. Offill, general sales consultant, George P. Reintjes Co., died recently. Prior to joining Reintjes, Mr. Offill served as vice president in charge of sales of Amsler Morton Corp. for 20 years.

Publication Service...

JANUARY, 1961

You Can Obtain . . .

. . . any of the bulletins reviewed in the Publication Service of the IRON AND STEEL ENGINEER without obligation or cost. Simply circle the desired item numbers on one of the prepaid postal cards and mail. The requests will be forwarded to the manufacturers involved who will send the bulletins to you.

Note: Post cards expire three months after publication date.

(1) Rotoblast Table-Rooms

Pangborn Corp. has published a 12-page bulletin describing their pushbutton controlled LK and LM rotoblast table-rooms designed to blast clean various-sized pieces ranging from small parts to castings or weldments up to 10 ft wide weighing as much as six tons. Illustrated field reports show how table-room installations are saving money and manhours on cleaning jobs which were previously done by other methods. In addition to photographs and cut-away diagrams, the bulletin gives complete dimensions and specifications of eight table-rooms, including the new "twin-table" type, showing how each may be tailored to particular requirements. (Bulletin No. 805)

(2) Mixer Type Welding Torches

The Oxweld W-45 and W-47 welding torches capable of welding any metal thickness from 28 gage sheet to heavy plate are described in a new eight-page booklet available from Linde Co., Division of Union Carbide Corp. Unique feature of the torches is their ability to handle gas flows as low as two cfhr for precision welding, or total flows as high as 1500 cfhr for heavy heating operations. Handy cutting attachments that quickly convert the torches from welding and heating to flame-cutting on all metal thicknesses up to 8-in. are described. Complete ordering information and performance data on a complete selection of welding heads and cutting nozzles is also included in the new folder. (Form 55-005)

(3) Rebuilding Distribution Transformers

General Electric Co., Service Shops Dept., has issued a bulletin describing their process of rebuilding old distribution transformers at considerable savings. The bulletin contains a chart showing the average life span of transformers and describes their transformer insulation system known as Permalex. (Bulletin GEA-7108)

(4) Circuit Breakers

I-T-E Circuit Breaker Co. has published a bulletin detailing their new current-limiting circuit breakers. The bulletin describes the equipment with information on selection and application. It also carries a section on dimensions and guide specifications. Four tables simplify supplemental information on protection of molded case circuit breakers in switchboards, motor control centers and panelboard, bus duct systems and other performance data. A graph showing "Amp-traplet-thru curves" is also included. (Bulletin No. 4300-1A)

(5) Ramming Mix

Available from H. K. Porter Co., Inc., Refractories Div., is a booklet describing their ramming mix. The booklet explains the properties, applications, advantages and chemical analysis of this burned magnesite-chrome basic brick. Installation data and information on where it may be purchased is also included.

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78	79	80	81	82	83	84	85			

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51	BLISS CO., E. W.	BULLETIN 40-B	Rolling mills
52	COLUMBUS McKINNON CHAIN DIV.	BULLETIN 100	Alloy sling chains
53	CUTLER-HAMMER INC.	PUB. LO-108-A-232	Lifting magnets
54	DELAVAL-HOLROYD INC.	BULLETIN 3800	Worm gear sets, worm gear speed reducers
55	DETRICK CO., M. H.	BULLETIN D-39	Monolithic refractory constructions
56	DIAMOND ELECTRONICS, DIV. OF DIAMOND POWER SPECIALTY CORP.		Industrial television
57	EATON MANUFACTURING CO., CLEVELAND WORM & GEAR DIV.	BULLETIN NO. 410	Speed reducers
58	ELECTRIC MACHINERY MFG. CO.	FOTO-FACTS NO. 16	Motor drives
59	ELWELL-PARKER ELECTRIC CO., THE		Industrial trucks
60	EUCLID ELECTRIC & MFG. CO., THE	BULLETIN 3004	Heavy-duty resistors
61	FOXBORO CO., THE	BULLETIN 21-10	Electronic control instruments
62	GARLOCK INC.	CATALOG 30	Oil seals
63	GENERAL ELECTRIC CO.	BULLETIN GEA-6701	Control panels
64	HEIL PROCESS EQUIPMENT CORP.		Steam jet agitators
65	HOMESTEAD VALVE MANUFACTURING CO.	REF. BOOK 39-2	Cam-Seald quarter-turn valves
66	LECTROMELT FURNACE DIV., McGRAW-EDISON CO.	CATALOG 10	Lectromelt furnaces
67	LEEDS & NORTHRUP CO.		Thermocouple
68	LINK-BELT CO.	BOOK 2760	Roller bearings and pillow blocks
69	LINK-BELT CO.	BOOK 2764	Coil conveyors
70	MARKAL CO.		Temperature indicators
71	PENNSYLVANIA CRUSHER DIV., BATH IRON WORKS CORP.	BULLETIN 9002 BULLETIN 3007	Ring-type granulators Coal processing machine
72	POST-GLOVER ELECTRIC CO., THE	BULLETIN NO. 500	Steel grid resistors
73	PRINGLE ELECTRICAL MANUFACTURING CO.		Disconnect switches for high-current equipment
74	RAMTITE CO., THE		Alumina ramming mix
75	RAMTITE CO., THE		Lining ladles
76	SPRAYING SYSTEMS CO.	BULLETIN 94	Heavy duty line strainers
77	SQUARE D CO., EC&M DIV.	BULLETIN 1300	Magnets and controllers
78	SQUARE D CO., EC&M DIV.	BULLETIN 6132	Magnetic control for d-c cranes
79	TAYLOR CHAIN CO., INC., S. G.	BULLETIN 14A	Alloy slings
80	TAYLOR INSTRUMENT COS.	BULLETIN 98268	Control system
81	TAYLOR INSTRUMENT COS.	BULLETIN 98286	Compact recorder
82	TAYLOR INSTRUMENT COS.	BULLETIN 98262	Potentiometer transmitter
83	WHEELABRATOR CORP.	BULLETIN 148-D	Descaling method
84	WHEELABRATOR CORP.	CATALOG 562-D	Ultra-filtration equipment
85	WHITING CORP.	CATALOG FY-168	Electric arc furnaces

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New heat-resistant alloy

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in Mahwah, N. J., Supertherm is field tested and proved. It is a superior alloy in this temperature range for static, centrifugal and shell-molded castings.

Mail the coupon, below, for technical information on composition*, physical and high-temperature properties.

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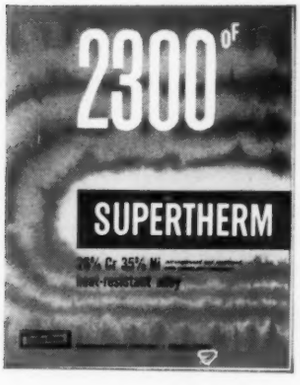

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Now Bethlehem forges every hardened steel roll from vacuum-degassed steel!

Bethlehem vacuum-degassed steel minimizes the hazard of roll breakage.

Pint size, king size, every in-between size. Now Bethlehem forges *every* hardened steel roll from vacuum-degassed steel.

PIONEER IN "VACUUM CASTING"

Bethlehem pioneered the development and use of vacuum-degassed ingots for highly stressed applications in the electric power, atomic energy, and other industries.

With our advanced steel-pouring techniques, we can pour molten steel from a furnace ladle to a secondary ladle within a vacuum chamber, and thereby remove harmful gases (we can also pour directly into a mold in the vacuum chamber). The secondary ladle is then taken out of the chamber and ingots of suitable size for hardened steel rolls can be cast under a blanket of inert gas.

LESS GAS MEANS SOUNDER STEEL

Because the vacuum-casting method reduces the volume of hydrogen and other gases, the steel is sounder, tougher, and cleaner than air-cast steel. It is this greater internal soundness which reduces the hazard of roll breakage.

OVER 350 ROLLS NOW IN SERVICE

In the past several years, we've produced and shipped more than 350 large, vacuum-degassed hardened steel rolls. The outstanding performance of these rolls confirms the superior soundness of vacuum-cast rolls as compared to air-cast rolls.

FAST DELIVERY . . . NO EXTRA COST

You have everything to gain (less roll breakage), nothing to lose (no price extra) by making your next purchase of hardened steel rolls Bethlehem vacuum-degassed rolls. Deliveries are excellent. Our sales offices are ready to give you the *whole* interesting story of this new Bethlehem development. Call or write the office nearest you today. Or write to us at Bethlehem, Pa.

Steel *for Strength ... Economy ... Versatility*

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BETHLEHEM STEEL

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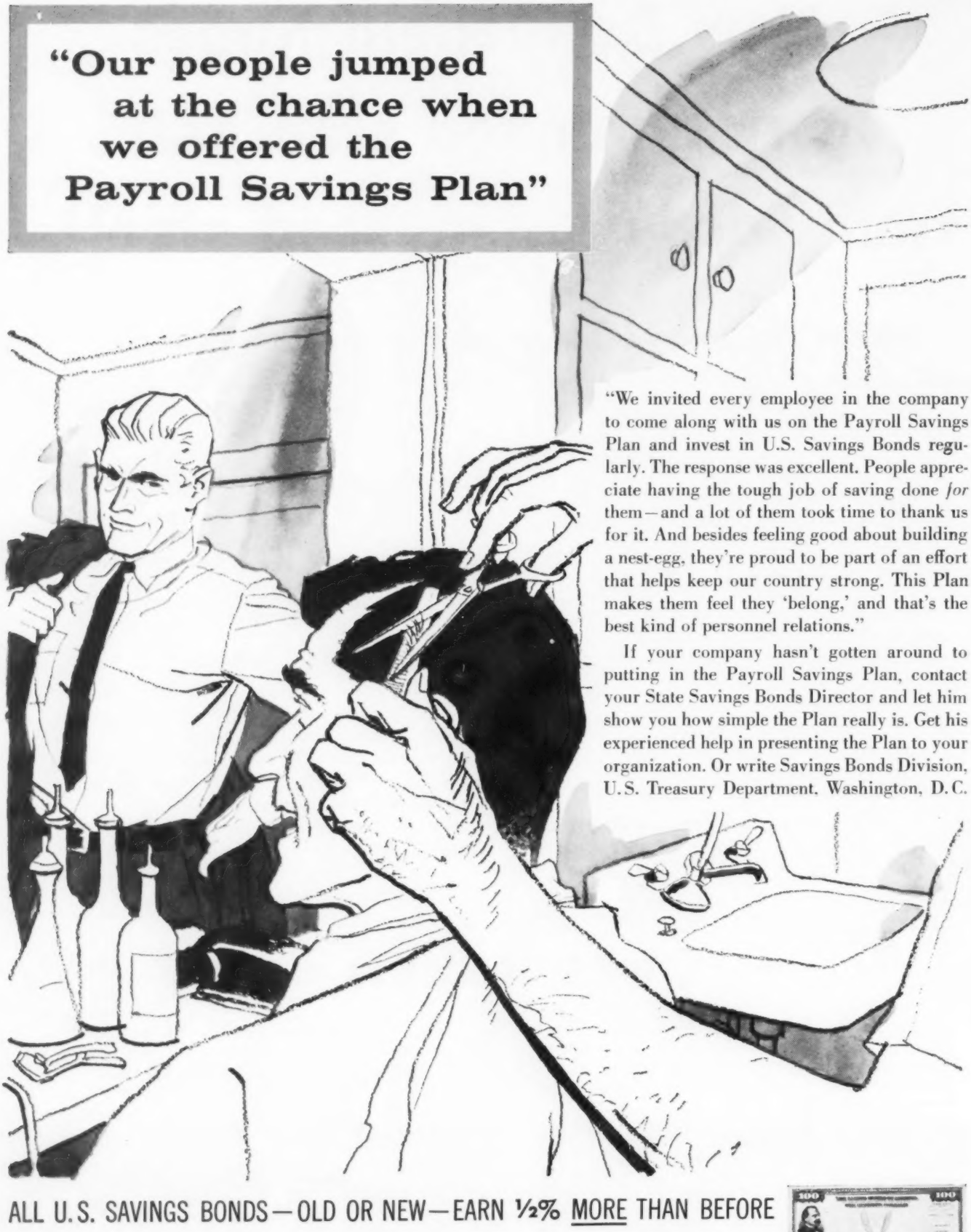
LOOK FOR THIS "V" STAMP on the ends of the rolls you buy . . . "V" is for vacuum. You'll find this permanent identification on every Bethlehem roll from now on . . . because from now on Bethlehem will forge *only* from vacuum-degassed steel.

LOOK FOR THIS LABEL on the packing of the hardened steel rolls you buy. It's your guarantee that your rolls are forged from Bethlehem vacuum-degassed steel . . . steel that minimizes the hazard of roll breakage in your plant.

"Our people jumped at the chance when we offered the Payroll Savings Plan"



"We invited every employee in the company to come along with us on the Payroll Savings Plan and invest in U.S. Savings Bonds regularly. The response was excellent. People appreciate having the tough job of saving done *for* them—and a lot of them took time to thank us for it. And besides feeling good about building a nest-egg, they're proud to be part of an effort that helps keep our country strong. This Plan makes them feel they 'belong,' and that's the best kind of personnel relations."

If your company hasn't gotten around to putting in the Payroll Savings Plan, contact your State Savings Bonds Director and let him show you how simple the Plan really is. Get his experienced help in presenting the Plan to your organization. Or write Savings Bonds Division, U.S. Treasury Department, Washington, D.C.

ALL U.S. SAVINGS BONDS—OLD OR NEW—EARN ½% MORE THAN BEFORE

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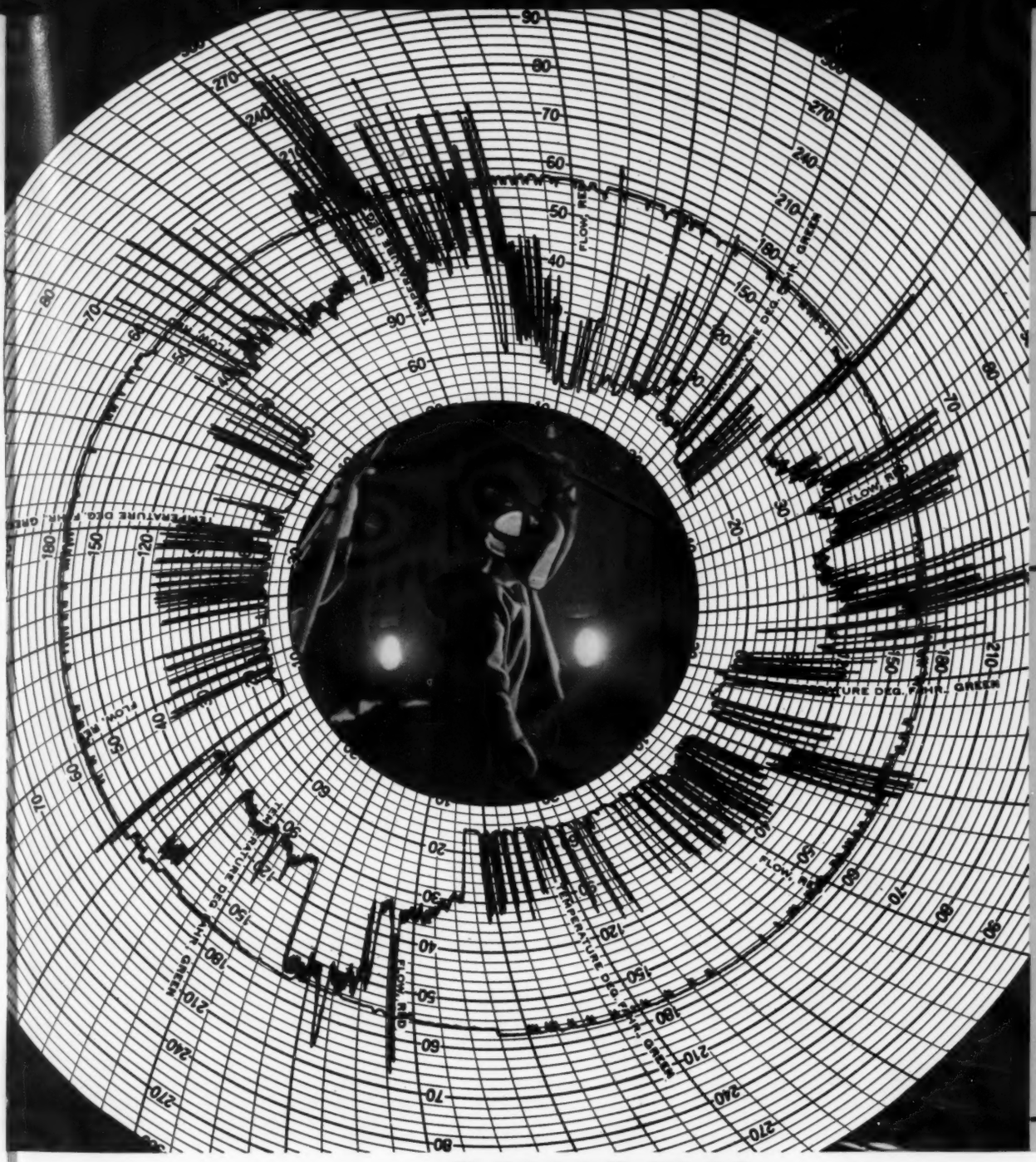
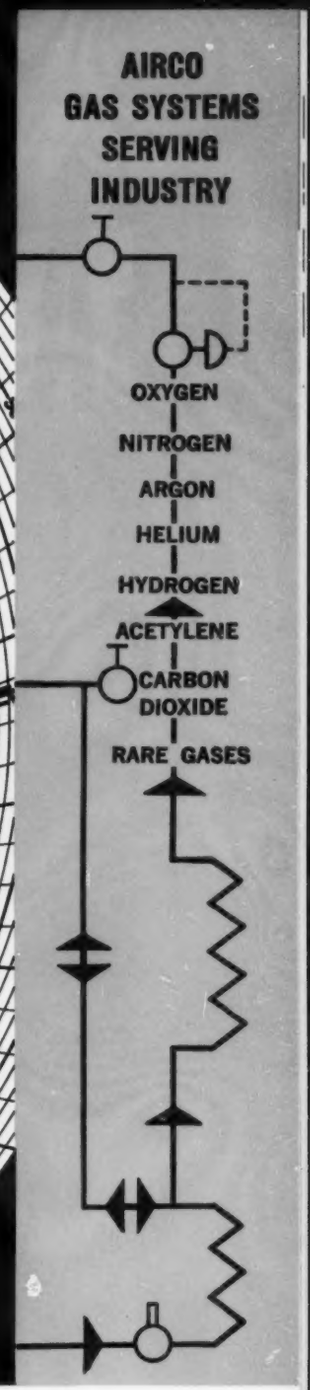
THE U. S. GOVERNMENT DOES NOT PAY FOR THIS ADVERTISEMENT. THE TREASURY DEPARTMENT THANKS, FOR THEIR PATRIOTISM, THE ADVERTISING COUNCIL AND THE DONOR ABOVE.





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in giant gulps or a steady flow...let an Airco on-site plant supply you

Looking for improvements in steel making? Airco built on-site plants supply users with plenty of oxygen . . . no matter how much you need.

This actual flow rate chart from a midwest mill pinpoints the story: this Airco on-site plant handles the surge demands right in stride. Whether flow rate demands are high or low, an on-site plant based on Airco gas experience is your assurance of high (99.5%) or low (95%) purity oxygen supplied with top efficiency.

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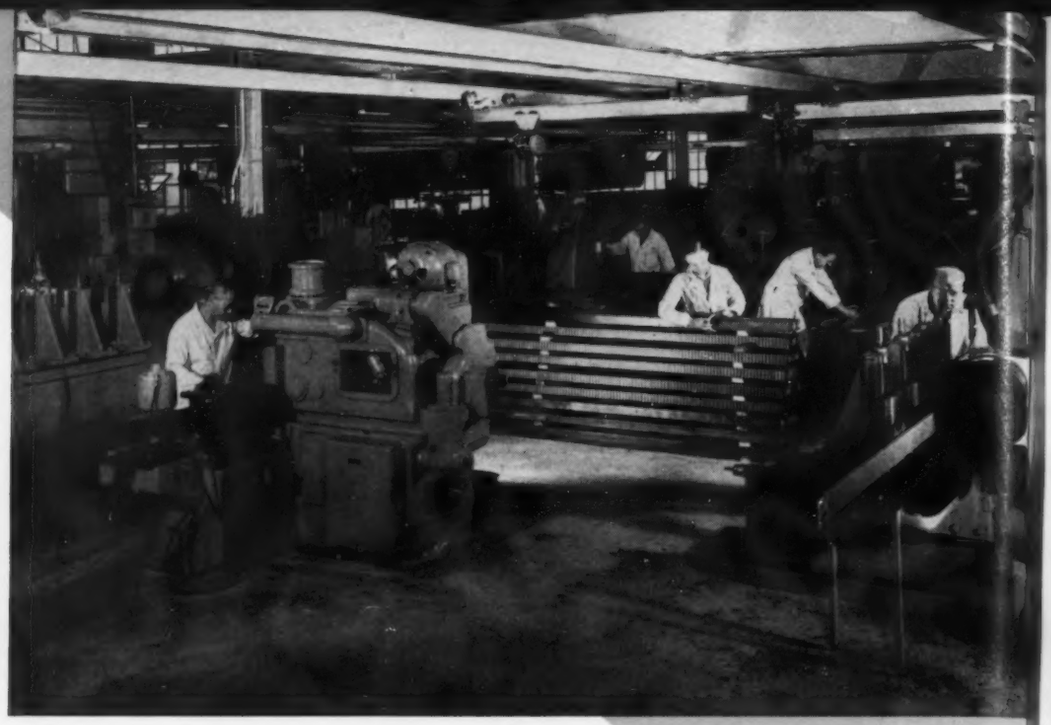
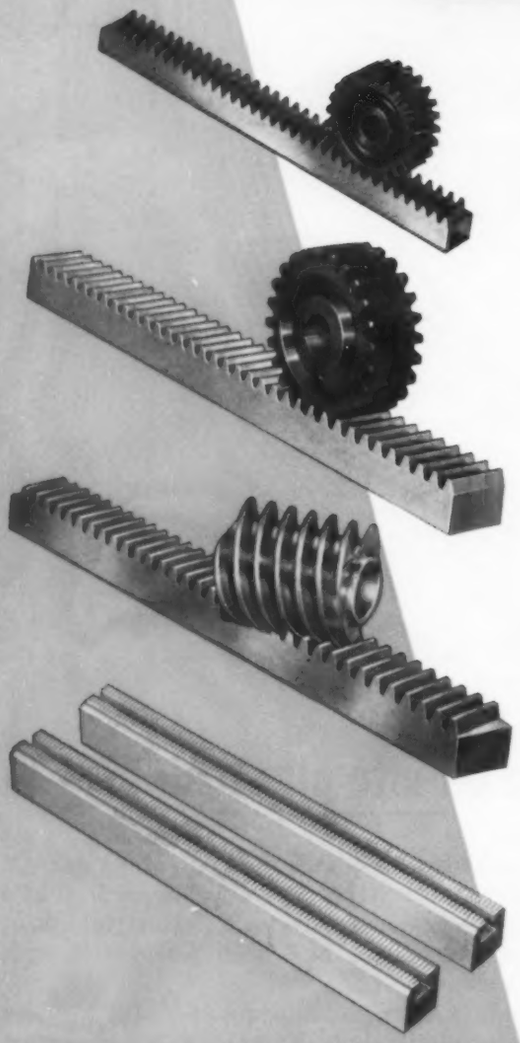
GEAR RACKS





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...any material

with quality as a first consideration

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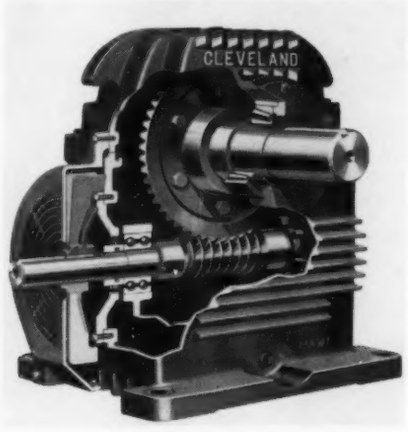
Equipment News...

SPEED REDUCERS

Δ A new line of worm gear speed reducers, available from Cleveland Worm and Gear Division, Eaton Manufacturing Co., offers horsepower capacities up to 80 per cent higher than those of conventional reducers of the same type. Space savings of 50 per cent and more are possible between two reducers of the same rating.

The new line is available in nine sizes ranging between 3-in. and 12-in. center distances. Ratios extend from 4⅓:1 to 95:1, ratings from fractional to 175 hp.

Advantages of the new reducers are due mainly to fan cooling. Plastic or aluminum is employed in the design of the extremely light, specially constructed radial fan which is equally effective in either direction of rotation. The fan is mounted on the input side of the worm shaft to efficiently scour



the finned outer wall of the reducer. Mounting in this position eliminates the extra expense and friction loss involved in the addition of another oil seal.

STRADDLE-TRUCK

Δ The instant response and positive control provided by hydraulic lifting are advantages contained in a new series of 20,000 and 30,000-lb capacity straddle truck carriers introduced by Hyster Co.

The all-hydraulic hoist system featured in new M200F and M300F straddle truck carriers reclaims power formerly lost in the levers, links, sprockets and chains of mechanical lifting arrangements. The result is greater load handling efficiency and a cut in handling costs.

Hydraulic systems of the M200F and M300F have a dual "heart," as two high-pressure pumps are utilized to supply hydraulic power. One pump supplies the power for the load shoe swing and to raise and lower the load; the other pump supplies the power steering.

A Hyster-designed flow motor equalizes pressure between the four hydraulic cylinders which raise and lower load shoes, insuring even and smooth upward and downward travel. When the load is raised, each hoist cylinder is locked in place by a specially-designed, four-way valve.

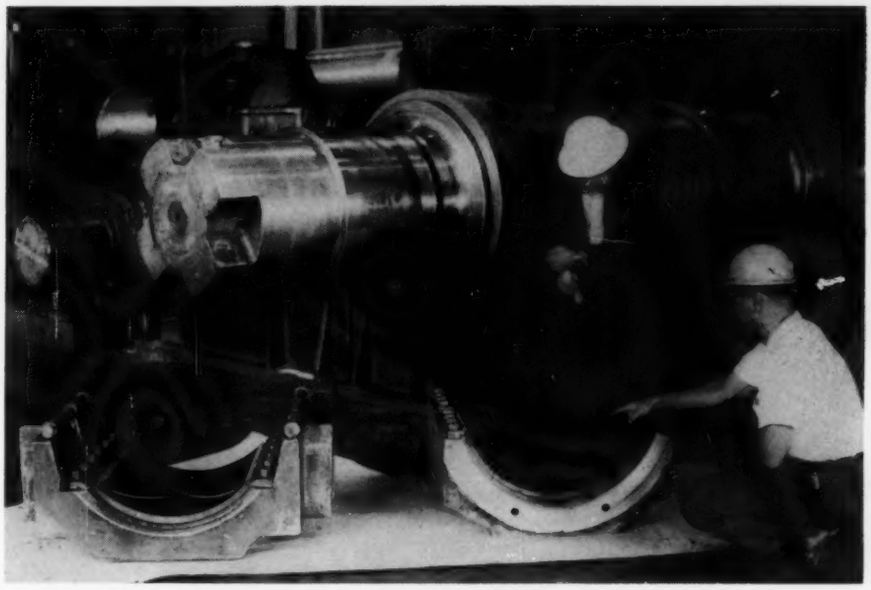
Hoist and swing control levers have been moved to the steering column, where they are conveniently located at the operator's fingertips.

An exclusive full-flow hydraulic oil filter removes impurities from the system which could clog and damage vital parts. All hydraulic fluid passes through the filter as it returns to the tank. The filter is so located that all "fill oil" must pass through the filter before it enters the hydraulic system. Long life of hydraulic components is assured with this exclusive feature.

A choice of two power plants is available—a 153-hp, V-8 gasoline or LP-Gas engine, or an 83-hp, six-cylinder diesel unit. Power is transmitted through a full-reversing, four-speed transmission and heavy-duty drive train.

A redesigned power steering unit reduces steering effort at low engine

BEARINGS FOR FAIRLESS SLABBING MILL



Replacements for long-life top roll bearing segments used in a 45-in. universal slabbing mill are examined prior to installation at the Fairless Works of U. S. Steel Corp. Made of Westinghouse Electric Corp.'s Micarta, a bonded phenolic laminate, the bearings are replacements for other Micarta bearings that were in service for almost half a year. During that period, the mill rolled in excess of a million tons of steel. These segments are grade T-36233 bearings, which are constructed of extremely heavy fabric, impregnated with a phenolic resin and lubricant included. The bearing material combines better cushioning effect with a low coefficient of friction at low speeds.

speeds. Power steering and power brakes allow the operator precise control of the maneuverable carriers.

Engine components requiring routine service and maintenance are positioned within easy reach. Wheel spindle supports may be quickly removed for tire changes. Accessibility and ease of maintenance have been designed into the trucks.

X-RAY GAGE

△ An x-ray gage, capable of penetrating carbon steel plate up to two in. thick, has been supplied to a leading steelmaker by Daystrom, Inc., Weston Instruments Division.

To be used on a hot reversing mill, the gage's sensing equipment is mounted in a "C" yoke with a 30-in. air gap between the pickup head above the plate and the x-ray source unit below.

The gage, which weighs more than 2 tons, has been heavily armored with half-inch steel plate. Complete water jacketing protects all heat-exposed parts.

Surface scale on the measured plate has a negligible effect on accuracy of the noncontacting gage. Maintenance of accuracy is assured by physical thickness standards built into a patented selector magazine.

Capable of indicating thickness deviations in thousandths of inches, the gage is equipped for remote setting from the operator's cab overlooking the runout table.

Push-button control is to be used to advance the gage's rugged, motor-driven carriage. In advancing to the measuring position, it will sense the edge of the plate and continue for a distance of six in. After remaining in this position for an adjustable number of seconds, the gage will retract to its stand-by location. Withdrawal of the gage carriage was specified by mill management to prevent any possible damage from plate moving into position for measuring.

At the operator's option, the gage can also be activated to traverse the entire width of the plate before withdrawing. In this way the gage provides a profile measurement of thickness from edge to edge.

HEAVY-DUTY COOLANT

△ A further development in synthetic coolants is announced by E. F. Houghton & Co. which is now marketing a water soluble base for heavy duty machining, an area previously limited to reinforced petroleum oils.

This base is high in both sulphur and chlorine providing anti-weld and extreme pressure properties which assure high finish and extended tool life. The base, when mixed with water, provides a stable emulsion even for long periods of continued use.

The product, known as Hocut No. 3210, has been thoroughly field-tested for a variety of uses and is recommended for machining of tough alloy steels, for threading, tapping and also as a stamping and drawing compound.

CONDUCTOR SYSTEM

△ A new medium capacity integrated current collector system, designated the C-Bar Conductor System, has been announced by Delta-Star Electric Division, H. K. Porter Co., Inc. The new system is used where load current requirements do not warrant the use of high capacity integrated systems.

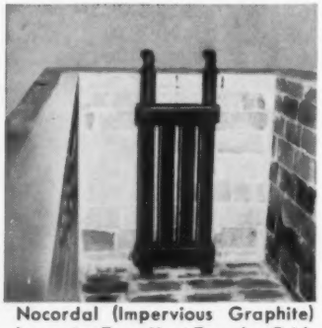
Developed by the division's Electric Service Works, the system is used for all types of a-c and d-c current collection on main runway and cross travel for traveling cranes,

material handling units, machine tools, etc.

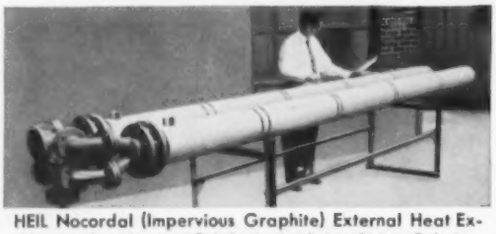
The new system is supplied complete with insulators, hangers, conductors and collectors, integrated as a package. It is ready for mounting on the wall of a building or on a structural support.

HEIL of Cleveland

Headquarters for TANK HEATING and AGITATION



Nocordal (Impervious Graphite) Immersion Type Heat Transfer Grid.



HEIL Nocordal (Impervious Graphite) External Heat Exchanger for Heating Sulphuric Acid Anodizing Solution.

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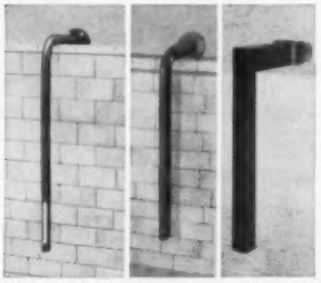

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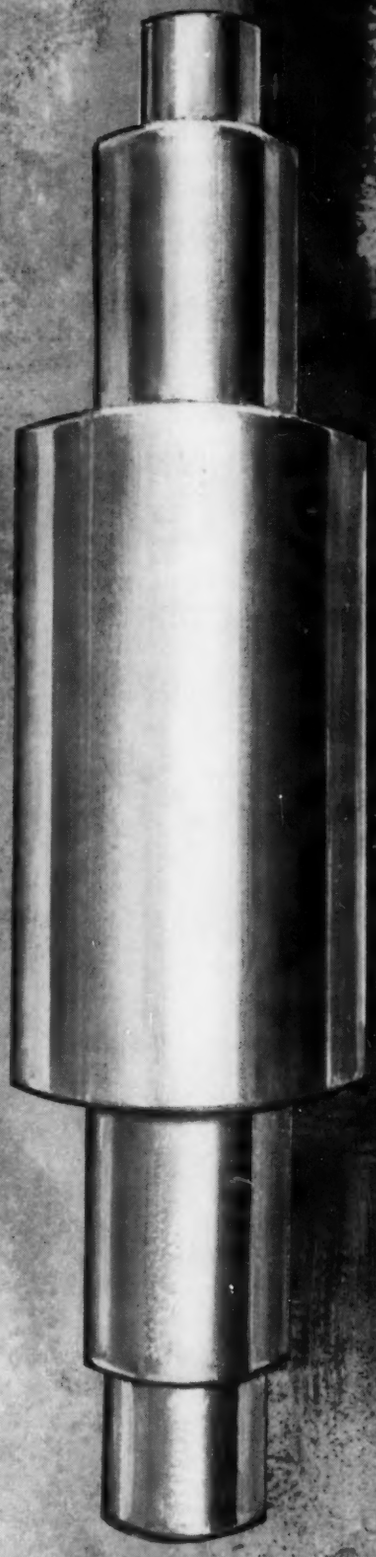
MARATHON FORGED STEEL ROLLS



MARATHON

SPECIALTY STEELS, INCORPORATED

A Division of Deutsche Edelstahlwerke A. G., Krefeld, West Germany DEW 375 Park Avenue, New York 22, N. Y.

Featuring compactness, rugged design and economy, the new system requires a minimum of space and is available in bronze, aluminum or copper. Continuous conductor current ratings are 350, 450 and 550 amperes. Collector ratings range from 50 to 250 amperes.

ELAPSED TIME METER

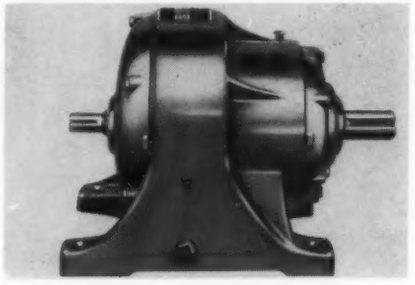
△ A new elapsed time meter (Type BH-351), with or without reset knob and mounted from either the front or back of the panel, is available from the Westinghouse Electric Corp.

Since the meter indicates the total time that a particular circuit is energized, it is suited for such applications as tube replacement programs and maintenance scheduling of electrical equipment, including diesel generators, motors, welders, and radio and television transmitters.

Six register wheels are provided, giving indication up to 99,999.9 hr. All digits are white on black background except the tenths digit, which is black on white.

SPEED REDUCER

△ U. S. Electrical Motors Inc. has developed double reduction SYNCROGEAR speed reducers incorporating an improved gear arrangement for low speed, high torque, extra capacity working performance. The speed reducers are provided in two types of gear train construction, depending on the rating of the unit: Type GDO with normal double reduction gear train and type GLO, also double reduction, but with a duplex gear arrangement.



Ideally suited for applications with space limitations, type GLO uses two primary gears and two final pinions to share the load from high speed pinion to slow speed output gear. Fully hardened, helical gears give maximum speed reduction and eliminate gear breakage caused from heavy duty loads. Use of a minimum number of parts in U. S. speed reducers minimizes excess wear and maintenance problems.

The reducers are designed to be driven by a separate, direct-connected motor. A direct connection may also be made on the take-off shaft or an indirect connection by means of a v-belt or chain drive. A solid cast, one piece, cast-iron housing eliminates misalinement problems and provides quieter operation by minimizing noise with its sound muffling qualities. Normalizing of castings for prevention of warping is also standard. During the actual motor operation, protection against motor reversal can be assured through the addition of an optional nonreverse backstop.

A highly effective lubrication system has been incorporated into the speed reducer. Included in its features are: a positive oil seal used

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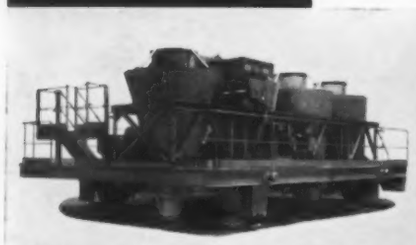
DOOR MACHINE

COKE
ON THE
MOVE

Operating economy and long life, again, are major advantages of Atlas equipment for highly specialized coke-producing service. Specially designed and ruggedly built to your exacting requirements.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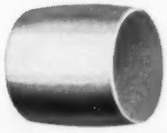
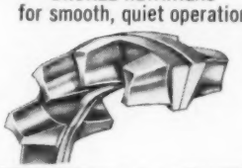
it's what's inside that counts!

MAXIMUM SIZE AND NUMBER OF ROLLERS for highest capacity



CENTRIFUGALLY CAST, PRECISION MACHINED BRONZE RETAINERS for smooth, quiet operation

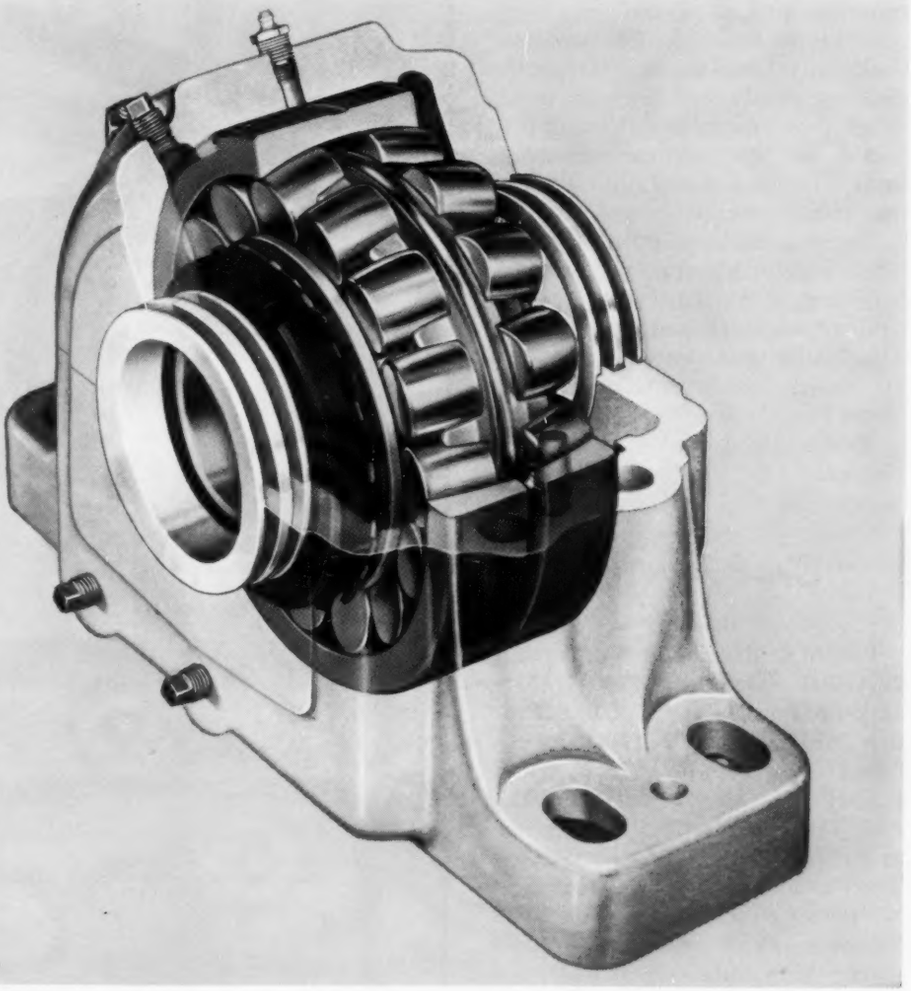


HIGH, HEAVY INNER RING FLANGES for ease of installation and removal

AND INSIDE LINK-BELT ROLLER BEARING BLOCKS you'll find Link-Belt's new spherical roller bearings . . . with big, mirror-smooth, highest capacity rollers; centrifugally cast, precision machined bronze retainers; heavy, broad-shouldered inner rings. *All* the best features of modern bearing design compactly unitized for utmost economy and long service life.

Link-Belt spherical roller bearing pillow blocks are self-aligning. Available in adapter mounting and direct-shaft mounting types for shafts from 1 7/16" to 12". Choice of two effective seals: all-purpose steel, multi-labyrinth seals, or Dacron-contact seals.

For full details, call your nearest Link-Belt office or authorized stock-carrying distributor. Look under BEARINGS in the yellow pages of your telephone directory. Ask for Book 2760.



SERIES 6800, 6900, 7800, 7900 have exceptionally rugged, two piece housings—machined as two perfectly matched parts providing easy installation.

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to prevent lubricant leakage out the high speed input shaft; and dip lubrication enabling precise amounts of lubrication to be used as required for operation at all speeds in either direction.

The reducers come in a broad range of capacities—⅓ to 75 hp with ratios from 5.00 to 47.4.

FRONT END LOADER

△ A specialized steel mill loader, the 136-RO Front End Loader, is now available from The Eimco Corp.

The 136-RO features a new operator position, developed exclusively for this model. The operator has been positioned high toward the rear of the machine, without disturbing other design features, such as center-mounting of the engine, finger tip control, dual final drives for power to each track, spin turn maneuverability, "Unidrive" transmission, and others.

It is possible for the massive bucket to be working in open hearth cleanout, while the operator position leaves him either outside of the furnace or the maximum distance from the heat and fumes within the furnace area.

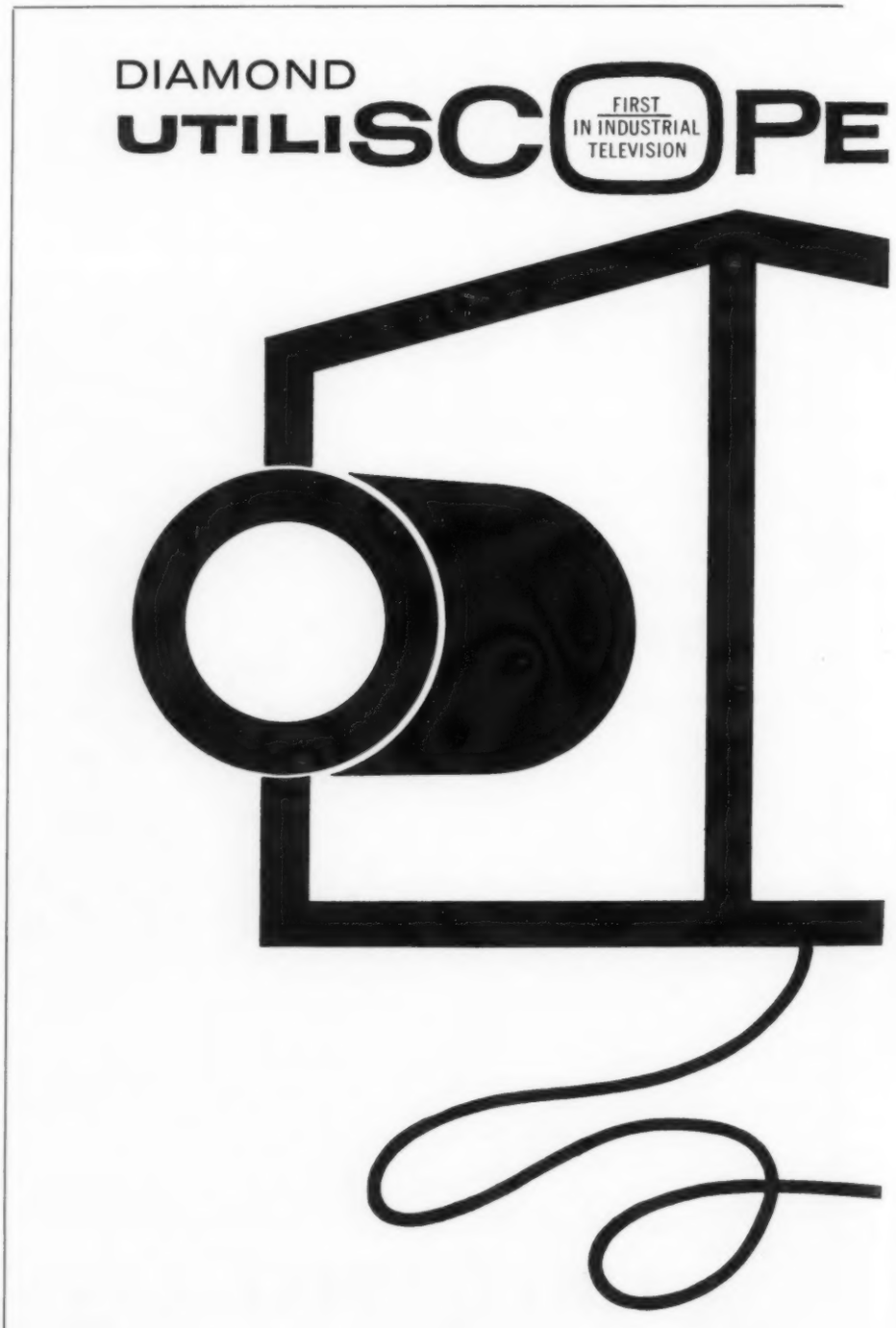
The new machine features special reinforced bucket and rail guards, is of rugged construction to easily handle this tough and rough work. The loader is powered by a 205 hp diesel V-6 engine of latest, modern and efficient design, and is protected by self-cleaning air cleaner.

Book Reviews

"NEMA Standards Publication 227-1960 (October, 1960)—Mercury-Arc Power Rectifier Units (Rolling Mill Service)" has been published recently by the National Electrical Manufacturers Assn., 155 East 44th St., New York 17, N. Y., and is available at $1.50 per copy. The publication applies to mercury-arc power rectifier units rated 1000 kw or more for continuous main-drive rolling mill service in which d-c motor reversal by armature voltage control is not required and in which any power regenerated by the motors is not returned to the alternating-current supply system.

"Research on the Rolling of Strip" has been published recently by the British Iron and Steel Research Assn., 11 Park Lane, London, W.1, England. The book contains 216 pages, 11 × 8½ in., is bound in light cardboard cover, and sells for $3.00 (postage and packing included) to nonmembers, free to BISRA members upon application by member firms' official representative. This work is a symposium of selected papers produced between 1948 and 1958. Seventeen papers are presented, complete with photographs, monographs, graphs and tables. The gradual development of practical and reliable methods of rolling mill calculations from basic theory is well illustrated in this symposium.

"NEMA Standards Publication TR 1-1960 (August, 1960)— Transformers, Regulators and Reactors" has been recently published by the National Electrical Manufacturers Assn., 155 East 44th St., New York 17, N. Y., and is available at $1.00 per copy. This revised publi-



cation is divided into 20 separate parts and includes general standards, test code, terminology and apparatus standards. It deals with distribution, power and regulating transformers, and such special-purpose transformers as those used in unit substations, electric arc furnaces and industrial rectifiers. It includes, by reference only, other existing publications for transformers, regulators and reactors as published by the American Standards Association, Inc., and NEMA. Insertion of these additional publications in the proper sections of TR 1-1960 will complete the NEMA Standards Publication and will result in a single comprehensive publication for transformers, regulators and reactors.

"The Extrusion of Metals" (second edition) by Claude E. Pearson and Redvers N. Parkins, has been published recently by John Wiley & Sons Inc., 440 Fourth Avenue, New York 16, N. Y. The book contains 336 pages, 5½ × 9 in., is cloth bound, and sells for $7.50. Notable progress has been made in the understanding of the complex deformation metals undergo during extrusion. Experimental work, coupled with mathematical treatment have enabled a theory of flow to be evolved which serves as a valuable guide to industrial practice. The subject matter is presented in 11 chapters which cover extrusion of lead and other soft metals, cable-sheathing; equipment for the hot extrusion of hard metals, flow of metals during extrusion, pressure of extrusion, theoretical analysis of flow in extrusion, metals and alloys for hot extrusion, the properties of extruded metals, the impact methods of extrusion, and some special applications of extrusion. Line drawings, charts and actual photographs amply illustrate the book.

"NEMA Standards Publication IC 2-1960 (September, 1960)—Resistance Welding Control" has been published recently by the National Electrical Manufacturers Assn., 155 East 44th St., New York 17, N. Y., and is available at $1.00 per copy. This standard contains information on the following: definitions; general information on ratings, tests, service conditions, etc.; connections; enclosures; magnetic and electronic welding contactors; types of controls; timer accuracies; frequency converter controls; accessories; definite applications; static switching control devices; type "J" controls; and symbols and device designations.

"Transformers and Generators for Power Systems," by R. Langlois-Berthelot (translated and revised in collaboration with Lieut-Colonel H. M. Clarke), has been published recently by the Philosophical Library, Inc., 15 East 40th Street, New York 16, N. Y. The book contains 541 pages, 6 × 9 in., is cloth bound, and sells for $12.00. This text is divided into two parts, the first dealing with the transformer and the second with the synchronous machine. The book has been aimed at simplification—a

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studied attempt to give the essential and enduring fundamentals that apply to both of these important equipments, stressing the essentials in clear and logical sequence, and at proper points reference is made to the original sources for a more comprehensive and detailed discussion of the subject. The book stresses practical information, orders of magnitude, a sense of proportion, guiding comments, significant factors of design and application. In addition, the book also discusses the essentials of design. Many equations, tables and line drawings are used to supplement and explain the text.

"Engineering Mathematics," by J. Blakey and M. Hutton, has been published recently by the Philosophical Library, Inc., 15 East 40th Street, New York 16, N. Y. The book contains 603 pages, 6 × 9 in., is cloth bound, and sells for $10.00. This book is based on Dr. Blakey's "University Mathematics" — the parts omitted are the chapters on Polar and General Equation of a Conic, and Solid Geometry. Four additional chapters have been compiled on Numerical Solution of Equations, Statistics, Relaxation Methods and Laplace Transforms. This book should amply cover the Pure Mathematics required for a degree in engineering at most universities.

"Mechanical Properties of Structural Materials at Low Temperature—A Compilation from the Literature," by R. M. McClintock and H. P. Gibbons, (National Bureau of Standards Monogram 13), has been published recently by the Bureau and is available from the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C., price $1.50. (Foreign remittances must be in U. S. exchange and should include an additional ¼ of the publication price to cover mailing costs.) The book contains 180 pages, 6 × 9 in., and is cloth bound. This monograph helps fill the need for a compilation of useful design figures and includes tensile strength, yield strength, tensile elongation, and impact energy of about 200 materials, metallic and nonmetallic, given graphically as functions of temperature between 4 and 300 degrees K.

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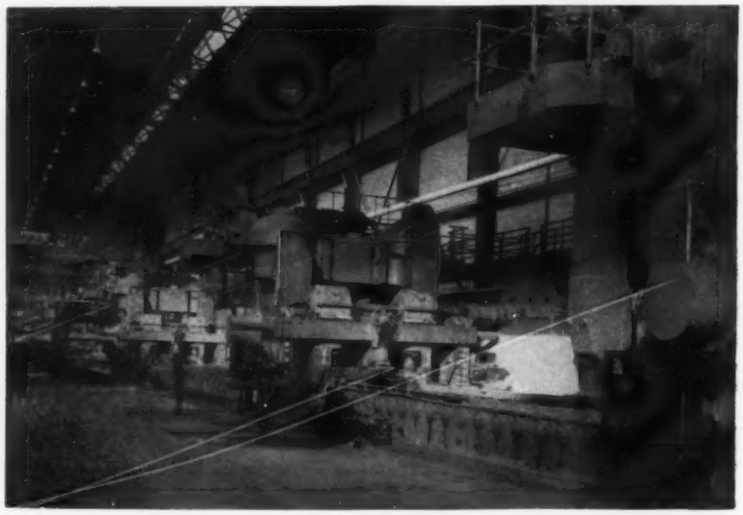

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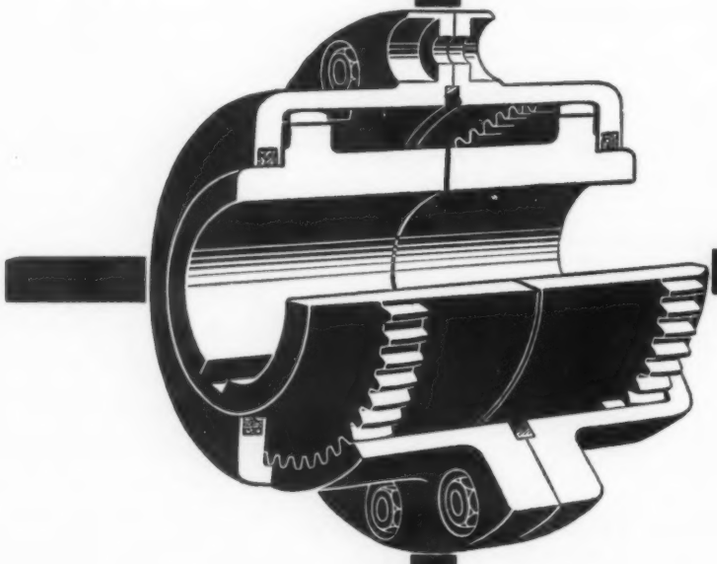

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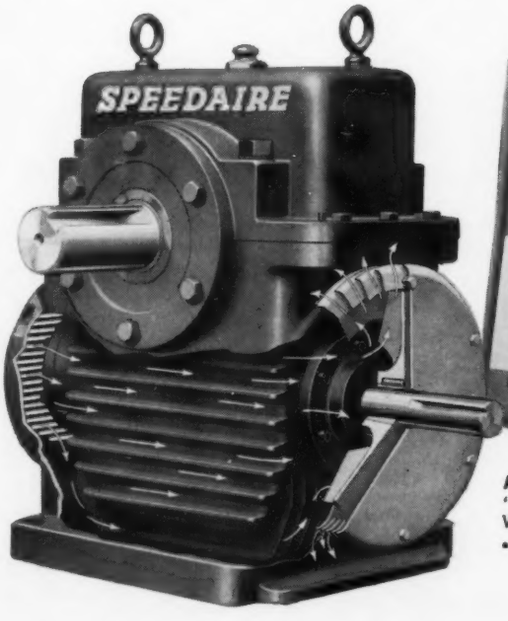

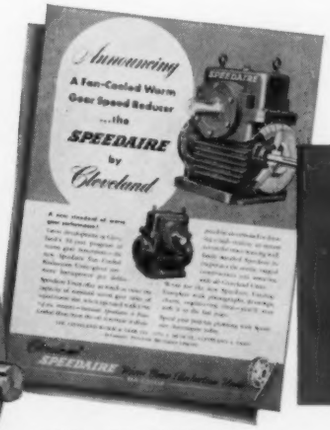

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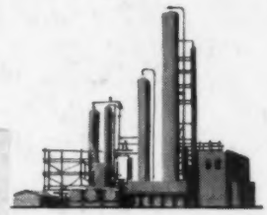

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